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Dendropoma cristatum (Biondi, 1859) - The vermetid reef from Favignana Island (TP), Sicily, Italy

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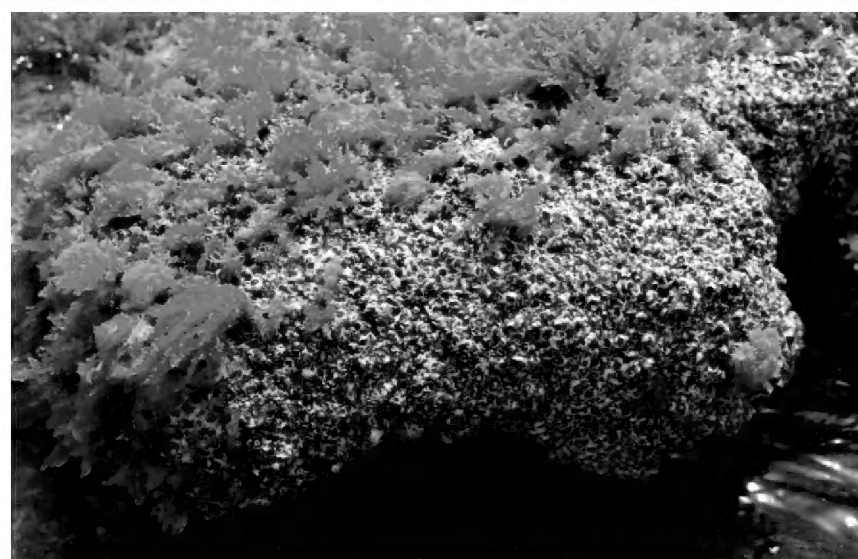
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The vermetid reefs. Vermetid reefs are bioconstructions built up by the gastropod mollusc *Dendropoma cristatum* (Biondi, 1859) in association with some coralline algae such as *Neogoniolithon brassica-florida* (Harvey) Setchell et Mason. These bioconstructions are unique and highly diverse systems that play a fundamental structural role, as they protect coasts from erosion, regulate sediment transport and accumulation, serve as carbon sinks, make the habitat more complex and heterogeneous and provide numerous habitats for animal and vegetal species thus increasing intertidal biodiversity. In Sicily, large and more or less continuous vermetid reefs are present along the north and northwestern coasts between Zafferano Cape and Trapani and within the Marine Protected Area (MPA) "Egadi Islands". These biogenic constructions, enclosed in the SPA/BIO Protocol (Barcelona Convention) are now threatened by environmental changes and human activities (e.g. pollution, climate change, ocean acidification) thus experiencing high mortality in several areas of the Mediterranean Sea.

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Dendropoma cristatum and its external structure.

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First evidence for the snake-eyed skink *Ablepharus kitaibelii* (Bibron et Bory de Saint-Vincent, 1833) (Sauria Scincidae) in Astypalea Island (Dodecanese, Greece)

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ABSTRACT

The first documentation (also with photos) on the presence of the snake-eyed skink *Ablepharus kitaibelii* (Bibron et Bory de Saint-Vincent, 1833) (Sauria Scincidae) in Astypalea Island (Dodecanese, Greece) is provided here. Until now, only five specimens in the Natural History Museum of Crete were known.

KEY WORDS

Ablepharus kitaibelii; Astypalea; Dodecanese; Snake-eyed skink.

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INTRODUCTION

The snake-eyed skink *Ablepharus kitaibelii* (Bibron et Bory de Saint-Vincent, 1833) (Sauria Scincidae) is the only species of the genus distributed in Europe and shows a distribution from southern Slovakia and Hungary, through most of Serbia, the eastern parts of continental Croatia, southern Romania, Bulgaria, Macedonia, Albania (lowland areas), Turkey (western and central), and Greece (Mainland, and many Ionian and Aegean Islands). As regards its range in the Aegean Islands, on Kos, Leros, Makronisi (SW of Lipsi), Nisyros, Tilos (Masseti, 1999), Chalki, Alimia, Symi, and Rhodes, it occurs with the nominate form *A. kitaibelii kitaibelii* (Bibron et Bory, 1833). On Karpathos, Kasos, Armathia, and Mikronisi (islets of Crete), *A. kitaibelii fabichi* Štěpánek, 1937 is present. On the island group of Kastellorizo and on the opposite southwest coast of Turkey, a cryptic species has been identified that seems to belong to a clade with features of both *A. kitaibelii* and *A.*

budaki, and which could be ascribed to *A. budaki anatolicus* Schmidtler, 1997 (Skourtanioti et al., 2016).

The occurrence of the snake-eyed skink *A. kitaibelii* in the Aegean Island of Astypalea (Dodecanese, Greece) is here reported for the first time.

MATERIAL AND METHODS

The data here presented came from field observation made by the authors on Astypalea Island during two different periods: August 2015 and April 2016. The individuals encountered were not captured or manipulated, but simply photographed in accordance with the Greek National Legislation (Presidential Decree 67/81). During the investigations, some young individuals of *A. kitaibelii* were sighted: a few in the immediate vicinity of a well located under the dam near the village of Livadhi, others along a boundary wall of an orchard inside Livadhi village (Fig. 1). Both situations were char-

acterized by moisture, supporting the hypothesis that *A. kitaibelii* is mainly a hygrophilous species. The individuals detected on Astypalea Island exhibited tails with orange-bright red colours (Fig. 2). Normally, the underside is greenish-blue or grey-white and in Transcaucasian and Thracian populations it appears reddish-orange (Gruber, 1981). As in the case with *Anatololacerta pelasgiana* on Tilos Island (Grano et al., 2018), a recent introduction can be assumed, since the only detected individual have been found in the immediate vicinity of Livadhi, the first most developed village on the island.

RESULTS AND CONCLUSIONS

Five specimens of *A. kitaibelii* from Astypalea Island preserved in the Natural History Museum of Crete (NHMC 80.3.82.25; NHMC80.3.82.256; NHMC80.3.82.257; NHMC80.3.82.85; NHMC 80.3.82.86) are known, but these data have not been published.

According to the Aegean distribution of this skink, it is likely to assume that on Astypalea Island the nominate form *A. kitaibelii kitaibelii* occurs. *Ablepharus kitaibelii* appears to be mainly a hygrophilous species (Cattaneo, 1998), as it generally lives on wet soil and in underwood bedding of



Figure 1. Study area near Livadhi village (Astypalea Island, Dodecanese, Greece).

conifers forests (Broggi, 2002; Wilson & Grillitsch, 2009). It was also observed in inhabited areas, probably driven by increased moisture. Astypalea looks like an enigmatic island because, despite its size and its discrete environmental heterogeneity, does not host snakes. Until now, only four lizards have been recorded in the island: *Hemidactylus turcicus* (Linnaeus, 1758), *Mediodactylus kotschy* (Steindachner, 1870), *Podarcis erhardii* (Bedriada, 1876), *Ophisops elegans* Ménétries, 1832 and one frog: *Pelophylax bedriagae* (Camerano, 1882).

The island is essentially hilly and is mainly characterized of limestone, whereas the area between the orographic series of the Mesa and the Exo Nisi (eastern and western part of the island) is constituted by flysch. Astypalea is mainly dry, but its karstic nature has given origin to water sources, especially in the western area. Moreover, in the Exo Nisi near Livadhi, there is a reservoir with a depth of 25 meters to supply water to the island. Astypalea suffers since ancient times of strong overgrazing by domestic and wild goats. In the past, the island was rich in forests, which have been destroyed by humans to use as farmland and pastures and as fuel in the lime kilns, which played a key role in the economy of Astypalea (Cattaneo & Grano, 2016). This probably led to an impoverishment of the local herpetofauna, as it was shown for the lizard of the genus *Podarcis* Wagler, 1830 (Pafilis et al., 2013). Despite a relatively long-standing tradition of herpetological research on the Greek islands (Pafilis, 2010), Astypalea ranks among those less considered, as there are no records of amphibians and reptiles with full field details available from the island (Uhrin & Benda, 2018).

Contributions relating data on herpetofauna of this island are provided by Zavattari (1929), Wettstein (1937, 1953), Beutler & Gruber (1977) and Angelici et al. (1990). Recently, an update on the presence of *Mediodactylus kotschy* and *Hemidactylus turcicus* on this island has been published by Uhrin & Benda (2018).

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Figure 2. *Ablepharus kitaibelii* from Livadhi village (Astypalea Island, Dodecanese, Greece).

REFERENCES

- Angelici F.M., Capula M. & Riga F., 1990. Notes on the herpetofauna of Astipalaia Island (Dodecanese, Greece). *British Herpetological Society Bulletin*, 34: 31–33.
- Beutler A. & Gruber U., 1977. Intraspezifische Untersuchungen an *Cyrtodactylus kotschy* (Steindachner, 1870): Reptilia: Gekkonidae. Beitrag zu einer mathematischen Definition des Begriff Unterart, *Spixiana*, München, 1: 165–202.
- Broggi M.F., 2002. Herpetological notes on the Dodecanese islands of Symi and Sesklia (Greece). *Herpetozoa*, 15: 186–187.
- Cattaneo A., 1998. Gli Anfibi e i Rettili delle isole greche di Skyros, Skopelos e Alonissos (Sporadi settentrionali). *Atti Società Italiana di Scienze Naturali del Museo civico di Storia naturale di Milano*, 139: 127–149.
- Cattaneo C. & Grano M., 2016. Contribution to the knowledge of vascular flora on Astypalea Island (Dodecanese, Greece). *Phytologia Balcanica*, 22: 405–417.
- Grano M., Cattaneo C. & Cattaneo A., 2018. Nuovo contributo alla conoscenza dell'erpetofauna dell'isola egea di Tilos (Dodecaneso, Grecia) (Amphibia et Reptilia). *Il Naturalista siciliano*, 42: 3–13.
- Gruber U., 1981. *Ablepharus kitaibelii* Bibron und Bory 1833. Johannisechse. In: Boehme W. (Ed.), *Handbuch der Reptilien und Amphibien Europas*, Bd. I, Echsen I, Akademische Verlagsgesellschaft, Wiesbaden, pp. 292–307.
- Masseti M., 1999. Terrestrial vertebrate fauna on Mediterranean islands: Tilos (Dodecanese, Greece) a case study. Abstracts of the 8th International Congress on the Zoogeography and Ecology of Greece and Adjacent Regions. Kavala, 172–1 May 1999. The Hellenic Zoological Society, Athens: 94.
- Pafilis P., 2010. A brief history of Greek herpetology. *Bonn Zoological Bulletin*, 57: 329–345.
- Pafilis P., Anastasiou I., Sagonas K. & Valakos E.D., 2013. Grazing by goats on islands affects the populations of an endemic Mediterranean lizard. *Journal of Zoology*, 290: 255–264.
- Skourtanioti E., Kapli P., Ilgaz C., Kumlutaş Y., Avci A., Ahmadzadeh F., Isailović J.C.N., Gherghel I., Lymberakis P. & Poulakakis N., 2016. A reinvestigation of phylogeny and divergence times of the *Ablepharus kitaibelii* species complex (Sauria, Scincidae) based on mtDNA and nuDNA genes. *Molecular Phylogenetics and Evolution*, 103: 199–214. <https://doi.org/10.1016/j.ympev.2016.07.005>
- Uhrin M. & Benda P., 2018. New records of *Mediodactylus kotschy* and *Hemidactylus turcicus* (Squamata: Gekkonidae) from Astypalea Island, Greece. *Herpetology Notes*, 11: 275–278.
- Wettstein O., 1937. Vierzehn neue Reptilienrassen von den südlichen Ägäischen Inseln. *Zoologischer Anzeiger*, 118: 79–90.

- Wettstein O., 1953. *Herpetologia Aegaea*. Sitzungsberichte der Akademie der Wissenschaften, mathematisch-naturwissenschaftliche Klasse, 162: 651–833.
- Wilson M.J. & Grillitsch H., 2009. The herpetofauna of Simi (Dodecanese, Greece) (Amphibia, Reptilia). *Herpetozoa*, 22: 99–113.
- Zavattari E., 1929. Ricerche faunistiche nelle Isole Italiane dell'Egeo. Anfibi e Rettili. *Archivio Zoologico Italiano*, 13: 31–36.

Update to the status of *Lindeni tetraphylla* (Vander Linden, 1825) (Odonata Gomphidae) in Italy, with special reference to the Molise region

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ABSTRACT

Data concerning a new reproductive population of *Lindenia tetraphylla* (Vander Linden, 1825) (Odonata Gomphidae), found by the authors in Molise, Central Italy, between 2012 and 2018, are here reported. The species was recorded in some artificial farm ponds of the inland agricultural area, where localized but conspicuous reproductive populations are annually found. A single sighting from 2017 is also reported from the Abruzzo region, where the species has never been recorded before. The data here discussed update the status for Italy and enlarge the known distribution area. All the sites where the species is found in Molise are listed and mapped, brief data concerning habitat used are also reported.

KEY WORDS

Lindenia tetraphylla; Molise region; status update Italy; small farm ponds.

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INTRODUCTION

Lindenia tetraphylla (Vander Linden, 1825), synonym *Lindenia inkiti* Bartenev, 1929 (Odonata Gomphidae), is an Irano-Turanian species, its main range spreading over the Eremian region, going from Central Asia to Arabia (Dumont, 1991; Giles, 1998; Schröter, 2010a; Waterston, 1984; Waterston & Pittaway, 1991; Skvortzov & Snegovaya, 2014). It is distributed also from Western Pakistan to the Caucasus region, the Levant and Turkey (mostly southern Anatolia) to the Western Mediterranean (Schneider, 1981, 1988; Schneider & Dumont, 1997, 2015; Schorr et al., 1998; Kalkman, 2006; Kalkman & Van Pelt, 2006; Borisov & Haritonov, 2008; Boudot et al., 2009; Schröter 2010a, 2010b; Boudot & Kalkman, 2015). It was

recently found in Bulgaria (Gastaron & Beshkov, 2010), where it is expanding its distribution (Kolev & Boudot, 2018), and Crete (Boudot et al., 2009, Boudot, 2014; Stille et al., 2014; Boudot & Kalkman, 2015) and is now considered resident in the western Balkans and Greece (Boudot & Kalkman, 2015; Lopau, 2010; Vilenica et al., 2016). It is a very mobile nomadic species (Fraser 1936; Schneider 1981). Adults are known to migrate over long distances from their reproductive locality (Boudot & Kalkman, 2015). Many out of range records may be referred to vagrant specimens, but some isolated localities were proved to be inhabited for several consecutive years, demonstrating at least a temporary reproduction far from its core range (Boudot & Kalkman, 2015). For example, the species has been recorded occasionally in the

Maghreb: in particular, it was considered reproductive in Tunisia in summer 2000 and 2002 (Kunz & Kunz, 2001; Boudot & Kalkman, 2015), while in Algeria, where it was considered previously extinct (Samraoui & Menai, 1999, Samraoui & Corbet, 2000; Boudot et al., 2009; Boudot & Kalkman, 2015), it was rediscovered in 2014 with evidence of reproduction in one site (Hamzaoui et al., 2015). As there is no continuous monitoring for these North African countries, its present status is unknown. In Europe, this species occurs in the Mediterranean basin, where it is very localized (Kalkman et al., 2010; Boudot & Kalkman, 2015).

The species is in fact listed as vulnerable in Annexes II and IV of the Habitats Directive (Kalkman et al., 2010). The type specimen is from Campania, Southern Italy, where no confirmed records were obtained in recent time. Elsewhere in Italy, the species was reported in the past during the mid 1800 to early 1900 (Sélys-Longchamps, 1843; Bentivoglio, 1910a,b, 1913), until recently (Utzeri, 2006; Riservato et al., 2014). In this note, we report data about a recently discovered Italian population, considered wealthy and rather relevant for the status of the species in Italy and Europe as well. After the first random discovery in 2012, when one male was photographed in Molise region (Central Italy), we yearly collected numerical and distributional data. In 2017, we observed a single specimen in Abruzzo region. The results are here briefly summarised.

MATERIAL AND METHODS

From 2012 to 2018, we have mapped all the suitable sites, therefore having the right environmental characteristics, in the Molise region (Figs. 1, 2). These sites consist of small-medium sized agricultural irrigation basins (Fig. 2). For each site considered, we annually performed at least two visits between June and August. Environmental characteristics, extension and GPS coordinates of all the sites where the species was found were noted. The coordinates were recorded using the UTM WGS84 33N reference system. Cartographic processing was done using QGIS 2.14 Essen. At each visit, the number of observed specimens, sex and age was noted when possible. Many of these specimens were captured with entomological nets for photo-

graphic documentation but, given the rarity of the species, they were all subsequently released (Figs. 3–6). The specimen observed in Abruzzo was detected during a study on the dragonflies of the Majella National Park, conducted in 2017 (Corso & Biscaccianti, ined.).

ABBREVIATIONS. AC: Andrea Corso; CF: Carlo Fracasso; ex/exx: specimen/specimens; max: maximum count; min: minimum count.

RESULTS

All the sites where the species has been found in Molise are shown in figure 2 and listed in Table 1. The first report for Molise refers to 1 mature male photographed on 16.VI.2012 by CF and determined by AC, in the site called Montorio nei Frentani (CB) (498129, 4625799) (Table 1). A few days later, on 29.VI.2012, at the same site, we observed up to a maximum of 20–25 exx (16 males, 4 females) (Figs. 3–6). On 30.VI.12 on the site called Laghetto Iacoluto, Salcito (CB), 4 males and 1 female were observed (Table 1). Between 2013 and 2018, the observation sites rose to six, for a total of 205 exx observed (min–max: 13–57 exx), mostly males, with an average of 29.3 exx per year and 34.2 per site (Table 1). The most relevant site was always the first one we discovered, with 148 exx in total observed in the seven years of study and a range of 8–50 exx. (average of 21.2 exx/year) (Table 1). Here in 2016 and 2017 at least 20 exuviae have been found along the muddy banks of the irrigated artificial basin (AC). For Abruzzo, we obtained a single observation, referred to 1 male observed on 18.VII.2017 in the Piana del Sagittario, between Sulmona and Pratola Peligna (L'Aquila) (4264695, 13522446) (AC & A. Pulvirenti, ined.). It is not clear, in the current state of knowledge, whether it was simply an erratic exemplar or if there is a small reproductive nucleus in the area that has so far escaped research.

Habitat characterized by arable crops with prevalence of cereal crops attributable to the land use category “arable land in non-irrigated areas” (CLC 211), within which there are artificial water basins created for irrigation purposes with an average size of about 150 square meters. In only one case (Sant’Angelo Limosano, Laghetto Cascapere) the lake is of natural origin. The distance from the

sea is on average 20 km (min–max: 2.4–43.9 km). In all cases, there is a dense vegetation along the banks, mainly *Phragmites* sp. and *Typha latifolia* (L.). The immediate vicinity is invariably wide cultivated fields with low and dense vegetation, flat or hilly, always very rich in numerous species of Or-

thoptera, one of the main prey of the species. The observation site of Abruzzo is a fluvial plain (Fiume Sagittario) with dense arboreal coverage, with numerous temporary flooded fields but with the presence of permanent scattered swampy areas with rich typhus and reed beds.



Figure 1. Typical habitat where *Lindenia tetraphylla* was found in Molise region, Central Italy.

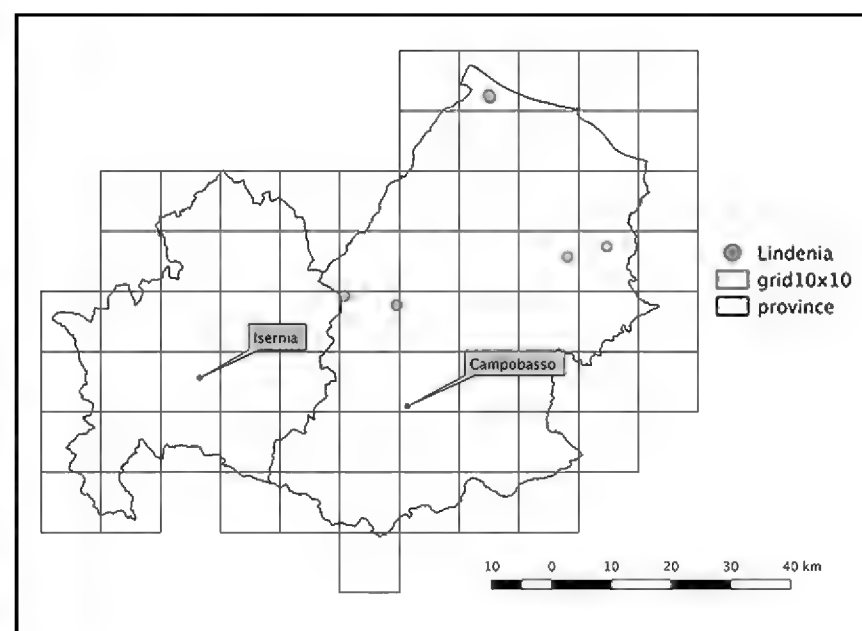
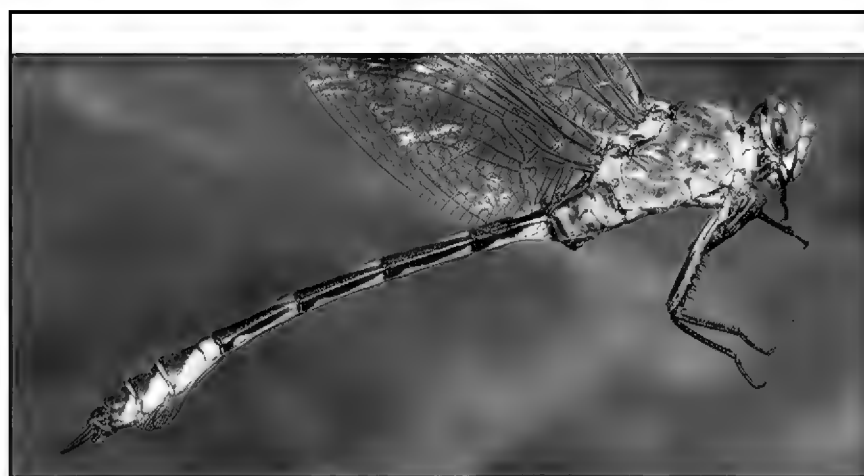


Figure 2. *Lindenia tetraphylla* in Molise region, Central Italy: in green are indicated the two provinces .



3



4



5



6

Figure 3. The first captured specimen of *Lindenia tetraphylla* from Molise region, Central Italy, 29.VI.2012 (photo A. Corso). Figures 4–6. Males of *L. tetraphylla* from Molise region, Central Italy (various date from 2013 to 2017) (photos C. Fracasso).

DISCUSSION

Stable reproductive populations for Tuscany and Sardinia, referred to about 10 different areas, have been reported and were considered the only in Italy. For the other known areas to date (about 15 additional sites), only anecdotal observations are available, like for Campania, Umbria, Puglia (Galletti, 1978; Terzani, 2002; Utzeri et al., 2006; Hardersen & Leo, 2011; Riservato et al., 2014). Even though there have been no confirmed recent observations for Campania and Lazio (Riservato et al., 2014; Janni & Corso, ined.), in 2017 a new reproduction site was reported for Sicily (Surdo, 2017).

For Abruzzo, no previous records were known (Riservato et al., 2014). Therefore, our observation is currently the first for the region. Here, more careful and extensive future studies will have to clarify its status and real distribution. The sites considered to be of major national importance were all located in Tuscany, for example those of Lago Accesa and Lago della Rancia, with observations referable to a maximum of 20–30 exx, and secondarily in Sar-

dinia (Utzeri, 2006; Hardersen & Leo, 2011). From what is available in the literature, the Molise population we discovered in 2012 should today be the most consistent in Italy, and at the current state of knowledge probably among the most relevant in Central and Western Europe (Boudot & Kalkman, 2015; Vilenica et al., 2016).

CONCLUSIONS

The species seems to be expanding its range: the increasing number of observation / reproduction stations discovered in Sardinia, Tuscany and Umbria, as well as from the new area in Sicily, in fact seem to indicate a positive trend (Hardersen & Leo, 2011; Surdo, 2017). However, we do not know if these data reflect a real colonization of new areas, or more simply a greater coverage of the territory and a greater effort in odonatological research, which actually happened in the last decade in Italy. It is probable that the colonization of Molise took place through the arrival of erratic individuals of Balkan origin rather than from Tuscany, even if it

SITO	UTM WGS 84 33N		Lat. Long.	2012	2013	2014	2015	2016	2017	2018
	X	Y								
Montorio nei Frentani	498129	4625799	41°47'0.80"N 14°58'38.25"E	5 exx (16.VI) 16♂♂, 4♀♀ (some mating pairs) (29.VI)	10 exx (16.VI) ≥15 exx (some mating pairs) (07.VII)	8 exx (22.VI) ≥5 exx (28.VII)	≥2♂♂ (21.VI) 15+ exx (some mating pairs) (12.VII)	≥10 exx (27.VI) 4 exx (14.VII)	>50 exx (14.VI) ≥4 exx (02.VII)	40 exx (16.VI) 12 exx (20.VII)
Salcito (Laghetto Iacolutto)	460786	4619256	41°43'27.25"N 14°31'42.64"E	4♂♂ 1♀ (30.VI)	X	X	X	1♂ (06.VII)	1♂ (05.VII)	2♂♂ (07.VII)
Sant'Angelo Limosano (Laghetto Cascapere)	469518	4617742	41°42'38.27"N 14°38'1.16"E	1♀ (30.VI)	X	X	0	0	0	0
Petacciato 1	485211	4652180	42° 1'18.09"N 14°49'16.35"E	/	/	/	/	>30 exx (27.VI) (several mating pairs) ≥2 exx (14.VII) ≥3 exx (17.VII)	≥2 exx (05.VII)	15 exx (15.VI)
Petacciato 2	484967	4652670	42° 1'33.19"N 14°49'5.44"E	/	/	/	/	≥ 1 ex (14.VII) 2 exx (17.VII)	0	1♂ (19.VII)
Ururi	504726	4627485	41°47'57.40"N 15° 3'25.30"E	/	/	/	/	/	≥ 2 exx (5.VII)	0

Table 1. Number of *Lindenia tetraphylla* observed per site in Molise region, central Italy, from 2012 to 2017. Site name and GPS coordinates are reported (both UTM WGS 84 33N X,Y that Latitude and Longitude), number of specimens (exx) per year (sex reported when noticed). The symbol X indicate that the site was not visited / site not known before (data lacking), 0 that no specimens were recorded. In brackets, date of observations and notes (as in mating pairs recorded).

is not possible to establish with certainty the origin of the colonizers. Further future researches are necessary in order to extend the knowledge related to its distribution in Molise, Abruzzo, Umbria and Sicily, as well as on the actual presence or not in Lazio and Campania, in order to collect more extensive data on the actual consistency of the populations present in Italy. In addition, targeted research should also be carried out in Puglia, where the species is likely to be found but it is yet to be discovered, while in Sicily a larger portion of territory should be monitored.

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REFERENCES

- Bentivoglio T., 1910a. La *Lindenia tetraphylla* in Italia. *Monitore zoologico italiano*, 21: 309.
- Bentivoglio T., 1910b. Cattura della *Lindenia tetraphylla* in Lucca. *Atti della Società toscana di scienze naturali*, Pisa, *Processi verbali*, 19: 59.
- Bentivoglio T., 1913. Nuove osservazioni sulla *Lindenia tetraphylla*. *Atti della Società toscana di scienze naturali*, Pisa, *Processi verbali*, 22: 20.
- Borisov S.N. & Haritonov A.Y., 2008. The dragonflies (Odonata) of Middle Asia. Part 2 (Anisoptera). *Euroasian Entomological Journal*, 7: 97–123.
- Boudot J.P., 2014. A brief observation of egg laying in *Lindenia tetraphylla* (Odonata: Gomphidae) on Kríti (Crete), Greece. *Notulae odonatologicae*, 8: 94–96.
- Boudot J.P. & Kalkman V. (Eds.), 2015. Atlas of the European dragonflies and damselflies. KNNV Publishing, The Netherlands, 384 pp.
- Boudot J.P., Kalkman V.J., Azpilicueta Amorín M., Bogdanović T., Cordero Rivera A., Degabriele G., Dommanget J.L., Ferreira S., Garrigós B., Jović M., Kotarac M., Lopau W., Marinov M., Mihoković N., Riservato E., Samraoui B. & Schneider W., 2009. Atlas of the Odonata of the Mediterranean and North Africa. *Libellula*, Supplement 9: 1–256.
- Dumont H.J., 1991. Fauna palaestina. Insecta V. Odonata of the Levant. Israel Academy of Sciences and Humanities, Jerusalem, 297 pp.
- Fraser F.C., 1936. The fauna of British India including Ceylon and Burma. Odonata. Volume 3. Taylor. & Francis, London, 461 pp.
- Galletti P.A., 1978. Nuovi reperti di *Lindenia tetraphylla* (V.L.) in Italia (Odonata, Gomphidae). *Bollettino della Società entomologica italiana*, 110: 223.
- Gastaron V. & Beshkov S., 2010. *Lindenia tetraphylla* (Vander Linden, 1825) (Odonata: Gomphidae) a new genus and species for the Bulgarian fauna. *The entomologist's record and journal of variation*, 122: 272–274.
- Giles G.B., 1998. An illustrated checklist of the damselflies and dragonflies of the United Arab Emirates. *Tribulus*, Bulletin of the Emirates Natural History Group, 8: 9–15.
- Hamzaoui D., Hafiane M., Mebarki M., Arab A., Alfarhan A. H. & Samraoui B., 2015. The Gomphidae of Algeria and the Maghreb: status, ecology and conservation (Insecta: Odonata). *International Journal of Odonatology*, 18: 1–17. <https://doi.org/10.1080/13887890.2015.1043655>
- Hardersen S. & Leo P., 2011. Dragonflies of Iglesiente (SW Sardinia) and additional records of rare or poorly known species from Sardinia (Odonata). In: Nardi G., Whitmore D., Bardiani M., Birtele D., Mason F., Spada L. & Cerretti P. (Eds.), *Biodiversity of Marganai and Montimannu (Sardinia). Research in the framework of the ICP Forests network. Conservazione Habitat Invertebrati*, 5: 243–253.
- Kalkman V.J., 2006. Key to the dragonflies of Turkey, including species known from Greece, Bulgaria, Lebanon, Syria, the Trans-Caucasus and Iran. *Brachytron*, 10: 3–82.
- Kalkman V.J. & Van Pelt G.J., 2006. New records of rare or uncommon dragonflies in Turkey (Odonata). *Brachytron*, 10: 154–162.
- Kalkman V.J., Boudot J.P., Bernard R., Conze K.J., De Knijf G., Dyatlova E., Ferreira S., Jović M., Ott J., Riservato E. & Sahlén G., 2010. European Red List of Dragonflies. Luxembourg: Publications Office of the European Union.
- Kolev N. & Boudot J.P., 2018. Evidence of reproduction of *Lindenia tetraphylla* in Bulgaria (Odonata: Gomphidae). *Notulae odonatologicae* 9: 11–17. <https://doi.org/10.5281/zenodo.1230417>

- Kunz B. & Kunz D., 2001. *Lindenia tetraphylla*: Wiederrund für Nordafrika (Odonata: Gomphidae). *Libellula*, 20: 79–85.
- Lopau W., 2010. Verbreitungsatlas der Libellen in Griechenland (Odonata). *Libellula*, Supplement 10: 51–53.
- Riservato E., Festi A., Fabbri R., Grieco C., Hardersen S., La Porta G., Landi F., Siesa M.E. & Utzeri C., 2014. Odonata. Atlante delle libellule italiane - Preliminare. Società Italiana per lo Studio e la Conservazione delle Libellule. Collana “le Scienze” (17), Edizioni Belvedere, Latina, 224 pp.
- Samraoui B. & Corbet P., 2000. The Odonata of Numidia, northeastern Algeria. Part I: status and distribution. *International Journal of Odonatology*, 3: 11–25.
- Samraoui B. & Menai R., 1999. A contribution to the study of Algerian Odonata. *International Journal of Odonatology*, 2: 145–165.
- Schneider W., 1981. Eine Massenwanderung von *Selysiothemis nigra* (Vander Linden, 1825) (Odonata: Macrodiplactidae) und *Lindenia tetraphylla* (Vander Linden, 1825) (Odonata: Gomphidae) in SüdJordanien. *Entomologische Zeitschrift*, 91: 97–102.
- Schneider W., 1988. Dragonflies (Odonata) of the Wahiba Sands and adjacent Areas, Eastern Oman. *Journal of Oman Studies Special Report*, 3: 377–388.
- Schneider W. & Dumont H.J., 1997. The dragonflies and damselflies (Insecta: Odonata) of Oman. An updated and annotated checklist. *Fauna of Saudi Arabia*, 16: 89–110.
- Schneider T. & Dumont H.J., 2015. Odonata records from southern Iran. *Notulae odonatologicae*, 8: 117–155.
- Sélys-Longchamps E., 1843. Notes sur quelques Odonates d'Europe. *Annales de la Société entomologique de France*, Paris, (2) 1: 107–109.
- Schorr M., Schneider W. & Dumont H.J., 1998. Ecology and distribution of *Lindenia tetraphylla* (Insecta, Odonata, Gomphidae): a review. *International Journal of Odonatology*, 1: 65–88.
- Schorr M., Schneider W. & Dumont H.J., 1998. Ecology and distribution of *Lindenia tetraphylla* (Insecta, Odonata, Gomphidae): a review. *International Journal of Odonatology*, 1: 65–68.
- Schröter A., 2010a. The Odonata of Kyrgyzstan, part I - Critical national checklist, annotated list of records and collected data of the summer half-years 2008 and 2009. *International Dragonfly Fund*, 28: 1–72.
- Schröter A., 2010b. On a collection of dragonflies from eastern Georgia, with the first record of *Sympetrum arenicolor* (Odonata: Libellulidae). *Libellula*, 29: 209–222.
- Skvortsov V.E. & Snegovaya N.Y., 2014. Additions to the knowledge of the Odonata fauna of Azerbaijan, with six new records. *Notulae odonatologicae*, 8: 67–76.
- Stille M., Stille B. & Schröter A., 2014. *Lindenia tetraphylla*, new for the island of Kérkira (Corfu), Greece (Odonata: Gomphidae). *Notulae odonatologicae*, 8: 77–116.
- Surdo S., 2017. First record of *Lindenia tetraphylla* (Vander Linden, 1825) and rediscovery of *Orthetrum nitidinerve* (Selys, 1841) in Sicily (Insecta Odonata). *Fragmenta Entomologica*, 49: 1–5. <https://doi.org/10.4081/fe.2017.263>
- Terzani F., 2002. Ricerche odonatologiche in Toscana. 8. La *Lindenia tetraphylla* (Van der Linden, 1825). *Quaderno di Studi e Notizie di Storia Naturale della Romagna*, 16 (suppl.): 5.
- Waterston A.R., 1984. Insects of Southern Arabia. Odonata from the Yemens and Saudi Arabia. *Fauna of Saudi Arabia*, 6: 451–472.
- Waterston A.R. & Pittaway A.R., 1991. The Odonata or Dragonflies of Oman and neighbouring territories. *Journal of Oman Studies*, 10: 131–168.
- Utzeri C., Belfiore C. & Peels F., 2006. Some new records of *Lindenia tetraphylla* (Vander Linden) in Italy (Anisoptera: Gomphidae). *Notulae odonatologicae*, 6: 90.
- Vilenica M., Alegro A., Koletić N. & Mihaljević Z., 2016. New evidence of *Lindenia tetraphylla* (Vander Linden, 1825) (Odonata, Gomphidae) reproduction at the North-Western border of its distribution. *Natura Croatica*, 25: 287–294. <https://doi.org/10.20302/NC.2016.25.24>

Reproductive cycle of the pelagic fish Saurel *Trachurus trachurus* (Linnaeus, 1758) (Perciformes Carangidae) Caught in the Gulf of Skikda (Algerian East Coast)

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ABSTRACT

The present study focuses on the reproductive biology of the small pelagic fish Saurel *Trachurus trachurus* (Linnaeus, 1758) (Perciformes Carangidae), fished in the Gulf of Skikda on the Algerian east coast on an annual cycle from July 2014 to June 2015. The study of average sex ratio variations gave an average annual value of 49.98% in favor of males. The gonado-somatic ratio and the macroscopic examination of the gonads allowed us to locate the period of reproduction between December and April. This report highlights a sexual cycle composed of three successive phases; a slow maturation started from July to November, a phase of significant sexual activity corresponding to the laying period (December-April) and a phase of sexual rest coinciding with the month of May when the gonads recover their masses. On a monthly basis, the evolution of the hepatosomatic ratio values is similar to that observed in the gonado-somatic ones, which leads us to believe that the origin of the energy reserves of the gonads is not the liver and that Saurel is a fat fish, i.e. lipid accumulation occurs in the muscles. The study of mesenteric reserves confirmed the origin of gonadal energetic deposits. The size of the first sexual maturity in males and females is respectively 14 cm and 13.65 cm.

KEY WORDS

Trachurus trachurus; Algerian east coast; reproduction; sex ratio; first sexual maturity.

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INTRODUCTION

The study of the reproductive cycle of fish, including assessment of the reproductive potential is extremely useful to a better management of fisheries resources and to ensure the sustainability of these resources on the bioeconomic level.

Several studies have been devoted to various aspects of the small pelagic fish Saurel *Trachurus trachurus* (Linnaeus, 1758) (Perciformes Carangi-

dae) (Letaconnoux, 1951; Maurin, 1954; Nikolsky, 1963; Lahaye, 1972; Macer, 1977; Fréon, 1984; Kartas & Guignard, 1984; Korichi, 1988; Wootton, 1998; Mézédjri, 2004; Mézédjri & Tahar, 2007; Robinson et al., 2008; FAO, 2013; Azzouz et al., 2015a, b, 2016, 2018).

In particular, the objective of this study is to establish a better understanding of the reproductive biology of Saurel *T. trachurus* in the Gulf of Skikda by studying the following parameters: sex Ratio,

Gonado-somatic and Hepato-Somatic ratio, adiposity, size of first sexual maturity and condition factor (K) during the sexual cycle.

MATERIAL AND METHODS

The biological study consists in studying the parameters which make it possible to know the biology of our species; this study was carried out on fish caught by purse seines at the level of the Gulf of Skikda during the period stretching between July 2014 and June 2015.

Just with the unloading, at the port of Stora, a sample of 1 to 4 kg taken each month. On each fish we carried out a series of measures (Table 1). The measures of length were made by using a meter with a precision of 1 mm, the total and emptied weights by means of a precision balance with an accuracy of 0.01 g, the gonadic and hepatic weights were obtained using a balance of precision with an accuracy of 0.0001 g.

The determination of sex and maturity stages was carried out according to the method recommended by ERH team (ERH, 1996), during the evaluation of national resources campaign. It consists in the determination of the maturity stages by means of a four-stage scale.

N°	Code	Description
1	Lt	Total length
2	Wt	Total Weight
3	We	Eviscerated Weight
4	Wgon	Weight gonadic
5	Whep	Hepatic Weight
6	Adip	Adiposity
7	Sex	Identification of sex and

Table 1. Measures done on fish for the reproduction survey.

For the species such as Sardine and Saurel, grease is white and covers the internal organs. To determine the degree of fattening, we used the empirical scale with four degrees recommended by the ERH team (ERH, 1996), which is a derivative of Nikolsky scale (Nikolsky, 1963).

Sex-Ratio

In our work used the formula which gives sex-ratio as a percentage by the following relation:

$$SR = (Males\ number / Total\ number) \times 100$$

Then, the chi-squared (χ^2) test was used to evaluate the variation of the actual values of the sex-ratio compared to the theoretical proportion 50% (Dagnélie, 2006). We supposed as hypothesis H0: sex-ratio = 50% and we tested this hypothesis by calculating the value χ^2_{obs} .

$$\chi^2 = (m^2 / F) + (f^2 / F) - n$$

With: m: males number, f: females number, n = m + f, F = n/2: absolute frequency for each sex.

When $\chi^2_{obs} \geq \chi^2_{1-\alpha}$ to 1 degree of freedom we rejected the null hypothesis H0 at the level $\alpha=0.05$. This test is valid only for number of males or females higher than 5 (Dagnélie, 2006).

Gonado-Somatic Ratio GSR

It is calculated starting from the relationship between the weight of the gonads (Wgon) and the eviscerated weight of fish (We). We used the weight of emptied specimens in the place of the total weight to eliminate the variations due to the repletion state of the stomach. The GSR was calculated for each individual according to the following formula (Kara, 1997):

$$RGS = (Wgon / We) \times 100$$

This report allowed us to follow over time the weight changes that occur in the gonads during a reproductive cycle, which allows us to understand their maturation and to determine mainly the laying period (Barnabe, 1976).

Hepato-Somatic Ratio HSR

This relationship is calculated between the hepatic weight (*Whep*) and eviscerated weight (*We*) according to the following formula (Kara, 1997):

$$RHS = (Whep/We) \times 100$$

Adiposity

Monthly variations of adiposity were assessed during the cycle of reproduction between July 2014 and June 2015. This made possible to follow the annual variations of the mesenteric greasy (ERH, 1996).

Size at First Sexual Maturity

The size of the first sexual maturity shows the legal minimum size of the fish that can be fished in order to maintain sufficient fertility to regenerate the stock. It is determined to be the size corresponding to 50% of mature individuals. It is estimated by calculation, for each size class, with an interval of 1 cm, and for each sex by considering the frequency of mature individuals in relation to the total number of the size class in question. The individuals concerned are only those caught during the Saurel breeding season, i.e. from December to April (Barnabe, 1976; Kara, 1997).

Condition Factor K

The condition factor *K* is an index allowing the assessment of the relative weight status of the studied individuals. According to Barnabe (1976), at equal size, fish of the same sex may have weight differences related to various factors such as feeding abundance or spawning period. It is expressed by the following relation:

$$K = \frac{P}{L^3} \times 100$$

or: *P* = eviscerated weight, *L* = total length.

In our case, we used the eviscerated weight to compensate the gonad weight fluctuations, as well as the calculated allometric no; to observe the

monthly changes in *K*. The global allometric coefficient calculated for each sex separately was also used to observe the variations of *K* as a function of a given class.

RESULTS

Sex-ratio

The monthly sex-ratio evolution revealed that out of a total of 923 examined individuals, there were 462 males and 461 females, giving a sex ratio of 49.98% in favor of males. This value is not significantly different from the theoretical value *SR* = 50% because $\chi^2 = 2.14$ and $P > 0.05$ therefore not significant at the level of $\alpha = 5\%$.

Overall, the sex ratio was still insignificant during the entire sampling period. During the months of October and January, we noted a sex ratio in favor of males with high significance at the level $\alpha = 1\%$ ($P \leq 0.01$). Thus, in May the number of females was slightly higher than the number of males with a *SR* = 36.84% and $\chi^2 = 3.94$ (significant at the $\alpha = 5\%$ level; $p \leq 0.05$) (Table 2).

Monthly Variations of the Gonado-Somatic Ratio (GSR)

Fluctuations in the gonado somatic ratio in *T. trachurus* showed a difference between the mean *GSR* values of females which were higher than those observed in males. In females we observed a downward phase extending from July 2014 (*GSR* = 0.83%) to October (*GSR* = 0.32%), followed by a net increase, from November (*GSR* = 0.76%) to the month of January 2015 (4.01%). In February, the *GSR* values dropped significantly to reach *GSR* = 0.37% in May, whereas growth restarted in June (*GSR* = 3.83%).

In males there was a slight decrease during the months July, August and September 2014 (*GSR* from 0.53% to 0.28%). *GSR* values began to increase in October (*GSR* = 0.54%) up to January 2015 (*GSR* = 2.05%). This value was followed by a decrease in the average value during the months of February, March, April, May and June when the growth reached its maximum value (*GSR* = 4.59%) (Fig. 1).

Month	N males	N females	Sex-ratio	χ^2_{obs}	
July-2012	43	63	40.5660	3.77358491	ns
August	47	47	50.0000	0.00000000	ns
September	46	41	52.8736	0.28735632	ns
October	47	25	65.2778	6.72222222	**
November	41	44	48.2353	0.10588235	ns
December	46	37	55.4217	0.97590361	ns
January-2013	48	24	66.6667	8.00000000	**
February	37	40	48.0519	0.11688312	ns
March	35	41	46.0526	0.47368421	ns
April	30	38	44.1176	0.94117647	ns
May	21	36	36.8421	3.94736842	*
June	21	25	45.6522	0.34782609	ns
Total	462	461	49.9798	2.14099064	ns

Table 2. Monthly sex ratio changes at Saurel in the Gulf of Skikda (Algeria) with $p > \alpha = 0.05$: (ns) not significant, $p \leq \alpha = 0.05$: (*) significant, $p \leq \alpha = 0.01$: (**) highly significant.

Monthly variations of the Hepato-Somatic Ratio (HSR)

As shown in figure 2, we observed, in females, the lowest values of HRS during the month of July 2014 until December (HSR = 0.58% and 0.70%, respectively), with a maximum recorded in March (HSR = 2.04%); then again a decreasing trend from April (HSR = 1.53%), to May (HSR = 1.08%) and in June (HSR = 1.29%).

In males, variations in HSR were similar but with values slightly lower than in females. The lowest values were observed around July 2014, September, October, November and December. There was an increase in the value of the report in January 2015 (HSR = 0.90%) until reaching the maximum value in March (HSR = 1.98%), then there was a fall in HSR values in April, May and June (down to 0.89%).

Monthly Variations of Adiposity

The monthly variations of adiposity in females as in males were observed. The highest peak was recorded in the month of November (adiposity = 2.00%), then the values decreased to the lowest threshold (adiposity = 1.00%) during the breeding season. Then another peak was recorded in April in females (adiposity = 1.45%) and in May for males (adiposity = 1.57%) then, again, a decreasing trend was observed (Fig. 3).

Size of the First Sexual Maturity

The evolution of the size of the first sexual maturity given by class size of the mature individuals according to the total length during the reproduction period (December/April) in *T. trachurus* where the gonads are at their maximum development, showed that the male Saurel from the Gulf of Skikda starts to participate in breeding at a size of Lt 50 = 14 cm (Fig. 4) and for the female Saurel Lt 50 = 13.65 cm (Fig. 5), so we did not observe significant difference between the size of the first sexual maturity of males and females.

Condition factor K

The average condition factor K ranged between K = 0.67 and K = 0.79 during the period under investigation, reflecting the general state of the fish as a function of physiological activities. We noted that the evolution of this index during the year was slightly stationary from July 2014 to June 2015. The highest value was recorded in March (K = 0.79) which reflects the good condition of Saurel whereas the minimum was observed in February (K = 0.67) showing a slight weight loss of fish (this is the period during which the laying takes place) (Fig. 6).

Variations in k-class size coefficients in males were slightly different from in females. The mean value recorded in males (K = 0.72) was the same value as that in females. These variations had no distinct appearance (Fig. 7)

DISCUSSION

The study of the sex-ratio variations during the period from July 2014 to June 2015 of the Saurel *T.*

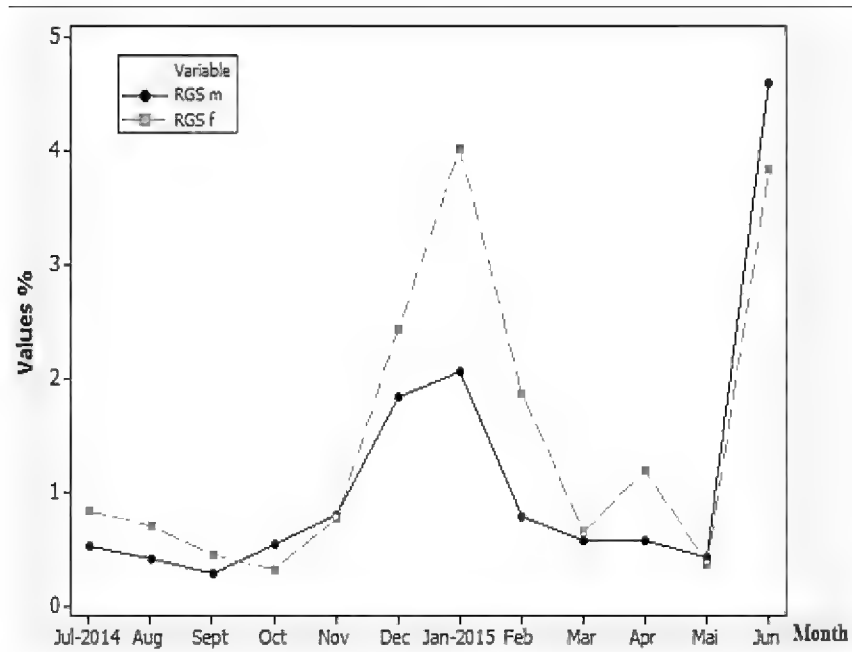


Figure 1. Monthly variations of GSR in *Trachurus trachurus*.

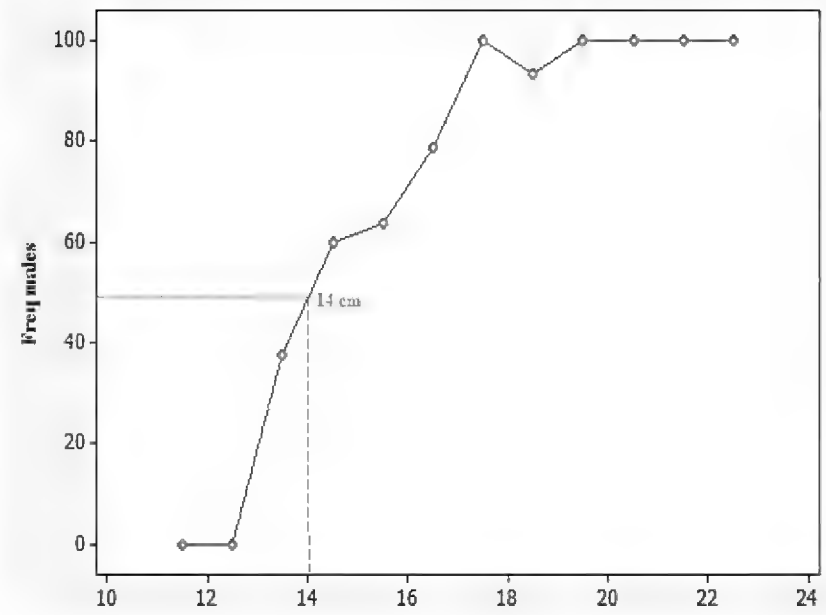


Figure 4. Size of first sexual maturity in males of *Trachurus trachurus*.

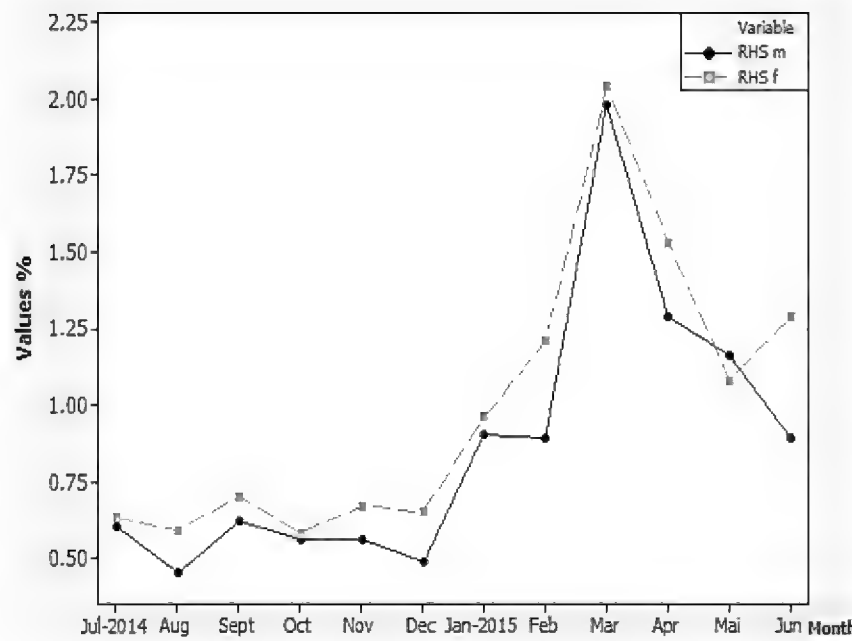


Figure 2. Monthly variations of HSR in *Trachurus trachurus*.

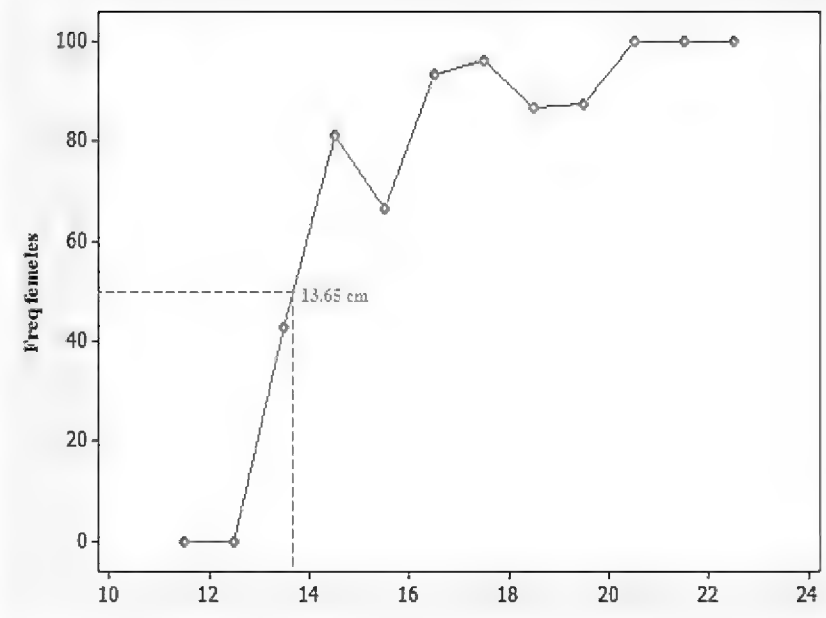


Figure 5. Size of first sexual maturity in females of *Trachurus trachurus*.

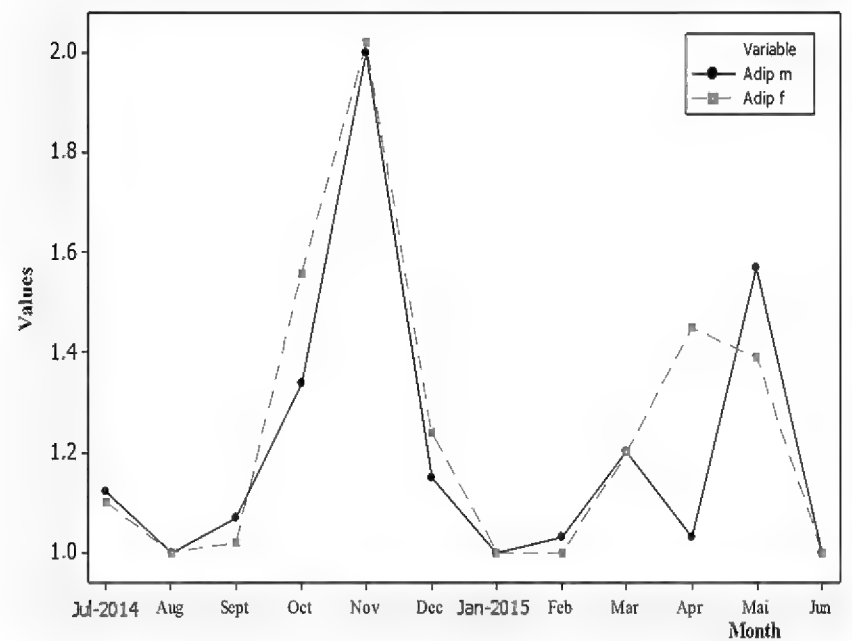


Figure 3. Monthly variations of adiposity in *Trachurus trachurus*.

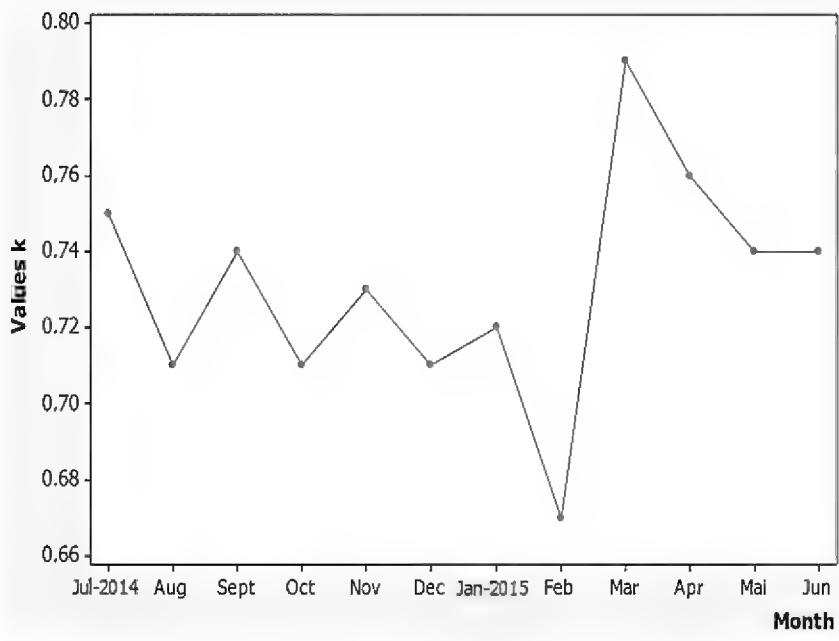


Figure 6. Monthly variations of K in *Trachurus trachurus*.

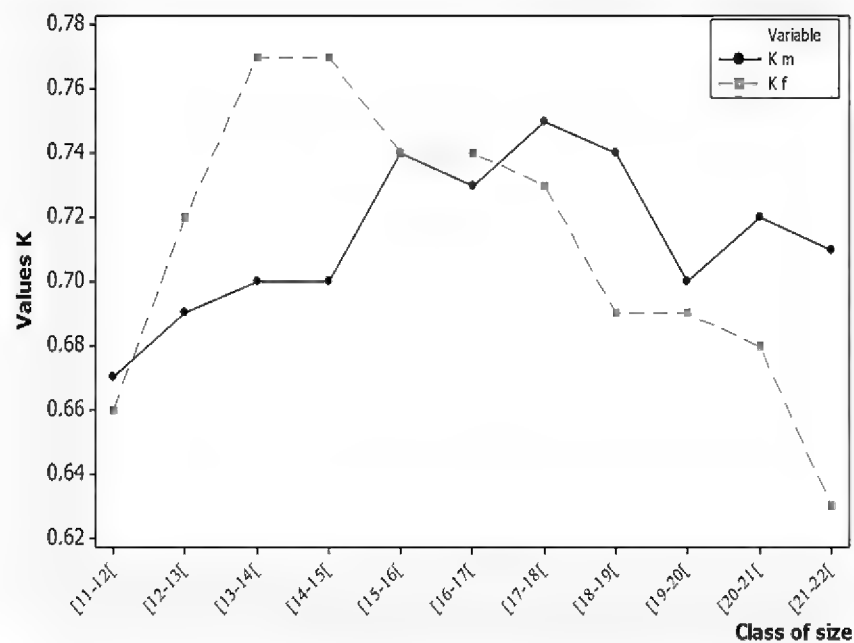


Figure 7. K Variations by Sex and Size classes in *Trachurus trachurus*.

trachurus of the Gulf of Skikda gave an average annual value of 49.98% in favor of the males, so overall, the males and the females were presented by almost equal proportions. Male sex ratio values were dominant in summer and fall, while females were dominant in winter and spring when breeding occurs.

Monitoring the monthly changes in GSR provides information on the periods of sexual activity and allowed us to establish that the saurel breeding season in our region occurs between December and April. GSR levels of females were higher than those of males because of the large size of the ovaries.

The values obtained for the evolution of the GSR showed that the studied sexual cycle comprises three phases: 1) slow maturation phase extending from the month of July and going on until the month of November when the GSR reaches the lowest values; 2) a phase of intense sexual activity from December to April, which is the period of laying where the RGS reaches the maximum; and 3) a phase of sexual rest that coincides with the month of May when the testicles and the ovaries recover their mass.

The peak observed in June 2015 was probably related to climate change and the high temperature recorded during the summer of 2015, so a breeding phase in Saurel was, probably, triggered.

The study of the monthly variations of the HSR showed that the necessary energy for the maturity of the gonads comes from the lipid reserves stored at the level of the liver. In both sexes one has the same pace but with slightly lower values in the

males. In general, during the maturation period, we had the lowest values of HSR followed by an increased peak of HSR during the breeding season. Therefore, these HSR variations showed an evolution almost similar to that of the GSR with maximum and minimum values reached at the same time, which suggests that the species is a fatty fish for which lipid accumulation occurs in the muscles (Bertin, 1958), and the liver does not intervene in the transfer of energy reserves (Djabahi & Hamida, 1989). As the liver plays no part in the process of maturation of sexual products, this implies that the two parameters (GSR, HSR) should be studied together and not separately, so these two indices are to be considered a good indicator of the metabolic state and energy reserves of fish.

With regard to mesenteric fat stores, values generally fluctuated throughout the sexual cycle in Saurel, there was a maximum peak implying an accumulation of reserves during the period of sexual rest and, still, maturation was followed by very low fat levels during the reproduction period, which confirms the origin of gonadal reserves (Djabali & Hamida, 1989).

The study of the size of the first sexual maturity based on the frequency of the mature individuals as a function of the total length (Lt 50) for which 50% of the individuals of the population are able to reproduce, made it possible to assess that for the males of *T. trachurus* the size of the first sexual maturity in the Gulf of Skikda during the studied period, July 2014–June 2015, is estimated as Lt 50 = 14 cm for males and Lt 50 = 13.65 cm for females.

The monthly evolution of this coefficient (K) in the Saurel *T. trachurus* of the Algerian east coast is slightly stationary throughout the sexual cycle, the lowest value showing a slight weight loss noted during the month of February which coincides perfectly with the period of laying where the reserves energy is consumed, followed by an increase in the value of K in the month of March, where the fish quickly recover their weight during the sexual rest period.

CONCLUSIONS

The biological study of the reproduction of Saurel samples taken from the Gulf of Skikda (Al-

gerian east coast) during the year July 2014 to June 2015 shows that: the reproduction of horse mackerel *T. trachurus* takes place once a year, apparently from December to April. The study of the sex-ratio shows that the males dominate (SR = 49.98%) The values obtained on the evolution of the Gonado-Somatic Ratio show that the sexual cycle studied passes by three successive phases, a phase of slow maturation, a phase of intense sexual activity and a phase of sexual rest. Variations of the Hepato-Somatic Ratio leads us to believe that the origin of the energetic reserves of the gonads is not the liver but, rather the muscles. The size of the first sexual maturity is reached at a length of 14 cm in males and females 13.65 cm. The monthly change in the condition factor (K) shows that our Saurel fish makes its energy reserves available during the breeding season and stores them during sexual rest.

REFERENCES

- Azzouz S., Tahar A. & Mezedjri L., 2015a. Influence des facteurs environnementaux sur la variabilité morphologique du Saurel *Trachurus trachurus* (Linnaeus, 1758) du littoral algérien. 6ème Journées Scientifiques Internationales sur la Valorisation des bioressources. Monastir, Tunisie (1–3 Mai 2015). Abstract book.
- Azzouz S., Tahar A. & Mezedjri L., 2015b. Contribution à l'étude des caractères morphométriques d'un poisson téléostéen le Saurel *Trachurus trachurus* (Linnaeus, 1758) du littoral algérien. IIIème Congrès International de Biotechnologie et Valorisation des Bio-Ressources (AT-BVBR). Tabarka, Tunisie (20–23 Mars 2015). Abstract book.
- Azzouz S., Mezedjri L. & Tahar A., 2016. Approche Morphométrique Comparée pour Identifier les Peuplements du Saurel *Trachurus trachurus* (Linnaeus, 1758) du littoral algérien. 6ème Colloque International Sciences & Environnement. Bizerte, Tunisie (21–23 Mars 2016). Abstract book.
- Azzouz S., Mezedjri L. & Tahar A., 2018. Comparative study on Saurel *Trachurus trachurus* fish (Linnaeus, 1758) obtained from the Algerian littoral using multivariate statistical methods (principal component analysis and hierarchical analysis). Journal of Biodiversity and Environmental Sciences, 13: 54–62, 2018. <http://www.innspub.net>.
- Bertin L., 1958. Sexualité et fécondation. In: Grassé P. P. (Ed.), Traité de Zoologie, Masson, Paris, 13.2: 1584–1652.
- Barnabe G., 1976. Contribution à la connaissance de la biologie du loup *Dicentrarchus labrax* (L.) (Poisson Serranidé). Thèse d'état, Université Montpellier Sciences et Techniques du Languedoc, 426 pp.
- Dagnélie P., 2006. Statistique théorique et appliquée. Tome 2: Inférences à une et à deux dimensions. Bruxelles, Université De Boeck & Larcier, 659 pp.
- Djabali F. & Hamida F., 1989. Pelagos. Bulletin de l'Institut des Sciences de la Mer et de l'Aménagement du Littoral, ISMAL, 7: 11–26.
- ERH, 1996. Evaluation de la ressource halieutique. Ministère des pêches et des ressources halieutiques. Rapport Campagne 1996, 40 pp.
- FAO, 2013. Species Fact Sheets *Trachurus trachurus* (Linnaeus, 1758), Food and Agriculture Organization of the United Nations. Fisheries and Aquaculture Department.
- Fréon P., 1984. La variabilité des tailles individuelles à l'intérieur des cohortes et des bancs de poisson, 1ère partie: observation et interprétation. Oceanologica Acta, 7: 457–468.
- Kara M.H., 1997. Cycle sexuel et fécondité du loup *Dicentrarchus labrax* (poisson Moronidé) du golfe d'Annaba. Cahiers de Biologie Marine, 38: 161–168.
- Kartas F. & Guignard J. P., 1984. La fécondité des poissons Téléostéens. Ed. Masson, 121 pp.
- Korichi H.S., 1988. Contribution à l'étude biologique des deux espèces de Saurels: *Trachurus trachurus* (Linnaeus, 1758) et *Trachurus mediterraneus* (Steindachner, 1868) et de la dynamique de *Trachurus trachurus* (Linnaeus, 1758) en baie de Bou-Ismaïl (Alger). Thèse de magister, ISMAL, Alger, 203 pp.
- Lahaye J., 1972. Cycles sexuels de quelques poissons plats des côtes de bretonnes. Revue des travaux de l'Institut des pêches maritimes, 36: 191–207.
- Letaconnoux R., 1951. Contribution à l'étude des espèces du genre *Trachurus* et spécialement du *Trachurus trachurus* (Linnaeus, 1758). Office Scientifique et Technique de Maritimes, Mémoire 15, 70 pp.
- Macer C.T., 1977. Some aspect of the biology of the horse mackerel (*Trachurus trachurus*) in water around Britain. Journal of Fish Biology, 10: 61–62.
- Maurin C., 1954. Les merlus du Maroc et leur pêche. Bulletin de l'Institut des pêches Maritimes du Maroc, Casablanca, 2: 7–65.
- Mézédjri L., 2004. Etude Biologique et Biométrique Comparée de l'anchois Européen *Engraulis encrasicolus* dans le golfe de Stora (Skikda) et le golfe de Lion (France). Mémoire de magister, Université Badji Mokhtar, Annaba, 106 pp.
- Mezedjri L. & Tahar A., 2007. Morphological variability, between two sites in Mediterranean population of the European anchovy: *Engraulis encrasicolus*. Journal of Fisheries International, 2: 65–68. <https://doi.org/jfish.2007.65.68>

- Nikolsky G.V., 1963. The ecology of fishes. Academy press, London and New York, 352 pp.
- Robinson M.S., Anthony T.R., Littau S.R., Herckes P., Nelson X., Poplin G.S. & Burgess J.L., 2008. Occupational PAH exposures during prescribed pile burns. *Annals of Occupational Hygiene*, 52: 497–508.
- Wootton R.J., 1998. Ecology of teleost fishes. Second edition. Fish and Fisheries, series 24. Dordrecht, Kluwer Academic Publishers, 386 pp.

The Ctenodactylidae (Rodentia) in northern Africa and a new location record for *Pectinator spekei* Blyth, 1856 in Afar National Regional State, Ethiopia

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ABSTRACT

The Ctenodactylidae is a small family of rodents comprising only five species in four genera. Four of the species are confined to North Africa in Mauritania, Morocco, Algeria, Tunisia, Libya, Senegal, Mali, Chad, and Niger. The fifth, *Pectinator spekei*, is the only one of the family that is found in the northeastern Horn of Africa. Earlier records have shown its presence in Somalia, Djibouti, Eritrea and eastern Ethiopia at altitudes below 1,200 meters. Sightings of this species in early November 2018 were at 13°17'47.7"N, 39°49'32.8"E at an altitude of 1,560 meters. This location is more than 300 km horizontally and almost 400 meters vertically from previous records. The IUCN Red List classification of least concern is strengthened by this new record in an area little disturbed by humans.

KEY WORDS

Biogeography; IUCN Red List; least concern; range extension; rodents.

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INTRODUCTION

The Ctenodactylidae Gervais, 1853 (Greek: “comb-toe”) is a unique family in the suborder Sciuravida of the order Rodentia. The family, whose members are sometimes known as “gundis”, comprises five extant species in four genera, but 16 extinct genera are known from fossils from Africa, Sicily (Italy), and parts of Asia. The family has no close relatives among current rodents and is a small relict cluster of evolutionary diversification that began in the Early Eocene from 54.8 to 49.0 million years ago (López-Antoñanzas & Knoll, 2011). These terrestrial animals inhabit rocky and sparsely vegetated areas that are characterized by low humidity and long sunny days.

All five extant species inhabit Africa north of the equator, four in Saharan regions of northern Africa and one - the main subject of this paper - in the Horn of Africa (López-Antoñanzas, 2016).

The first described of the extant species is *Ctenodactylus gundi* (Rothmann, 1776). This species is found in a narrow band from southeast of Fez in Morocco across Algeria and Tunisia to the West of Tripoli in Libya at altitudes ranging from 230 to 2900 meters. A part of this tract is included in protected areas and the species is classed as of least concern by IUCN (Aulagnier, 2008).

Massoutiera mzabi (Lataste, 1881) occupies the most desertic areas of the family, in the central Sahara regions of Algeria (Tassili n'Ajiers, Hoggar, Tefedest and Mouydir) and around the plateau of Tademait and the Mzab Valley, whence it is named (Gouat et al., 2009). It is also present in northeastern Mali, northern Niger, northwestern Chad and probably in Libya (Cassola, 2016a). The “Mzab gundi” occurs at elevations of 500-2,500 metres, is present in several protected areas and is classified as of least concern by IUCN (Cassola, 2016a). The most southerly of the Saharan species is *Felovia vae*

Lataste, 1886, classified by IUCN as of least concern (Gerrie et al., 2017). This “Felou Gundi” occurs through much of central and southern Mauritania with small extensions into northwestern Mali and possibly into eastern Senegal (Gerrie et al., 2017) and has been described as a mountain specialist (Brito et al., 2010). The fourth and most recently described of the Saharan species is *Ctenodactylus vali* Thomas 1902, sometimes known as “Val’s Gundi”. *Ctenodactylus vali* occurs in two isolated populations: the one astride the Morocco/Algeria boundary to the East of Marakech, the other in a small area of Libya to the South of Tripoli (Gerrie & Kennerley, 2016). Relatively little is known of this species and it is classified by IUCN as data deficient (Gerrie & Kennerley, 2016).

The only member of the Ctenodactylidae that is not found in the Saharan area is *Pectinator spekei* Blyth, 1856. The type locality of “Speke’s Gundi” is in Somalia between Las Koreh and the Nogal valley (09°N; 47°E) - now in Puntland State of northeastern Somalia - but its distribution in Somalia is unclear. Elsewhere, the species has been recorded from Djibouti, Eritrea and Ethiopia. Most early records were from what is now Djibouti in the Tadjoura Bay and Obock areas at about 12°N; 43°E and from around Assab at about 13°N; 43°E (now in Eritrea but originally part of Ethiopia). Later records made by Dr W George of Lady Margaret Hall, Oxford University, probably in the early 1970s, are from the lowland area of the extreme east of Ethiopia in an area bounded by 9° to 12°N and 41° to 42°E (Yalden et al., 1976: 61). A recent study has again recorded *P. spekei* in Djibouti in an area of sand and rocks with low scrub and some trees (Pearch et al., 2002).

A checklist of Ethiopian mammals give the zoogeographic region of SA (= Somali-arid) as the habitat of the species at altitudes of sea level to 1200 metres with a suggestion (without supporting evidence, of a possible altitudinal upper limit of 2200 metres (Yalden et al., 1996). It is recorded that this species is an inhabitant of rocky cliffs (sheltering in rock fissures) in desert or semi-desert areas and that it is sometimes found in association with hyraxes (Yalden et al., 1976).

Following Yalden et al. (1976), this species is characterized by: “*The short, well-furred tail and*

stiff white bristles covering the claws are probably sufficient to distinguish this species, which looks superficially like a small ground squirrel”.

RESULTS AND CONCLUSIONS

Several animals conforming to this description (Yalden et al., 1976) were seen basking and moving about on rocks at 16:23 hours East African Time (GMT +3) on 5 November 2018 (Fig. 1, Fig. 2). The location at 13°17'47.7" N, 39°49'32.8" E (Fig. 3) at an altitude of 1,560 m on the wall of the rift valley is 10 km circa South of the District Administrative centre at Abala (also known as Shiket) in Afar Region and about 3 km East of the Afar-Tigray regional boundary. The vegetation here has been described as sub-desert scrub growing on shallow soils over limestone parent material. At this particular site, described in detail in 1974, 32 species of trees and shrubs were identified with three species of Commiphora being dominant (24%), followed by *Acacia mellifera* (18%), *Grewia erythraea* (12%), and *Grewia mollis* (9%) (Wilson, 1977). In November 2018 the vegetative composition, with a very sparse field layer of grasses and herbs among rock outcrops had superficially not changed from the assessment of 1974 (Fig. 4).

This new location record for *Pectinator spekei* represents considerable horizontal and vertical range extensions compared to earlier records. It is 310 km West and 47 km North of earlier Assab records and 322 km and 185 km North of the cluster of records listed by Dr George (Yalden et al., 1976). At an elevation of 1,560 metres above sea level this new site is almost 400 metres higher than previously accepted elevations.

IUCN lists the species as being of least concern (Cassola, 2016b). This classification results from its relatively wide distribution, a presumed large overall population and a lack of significant threats. In this range extension area there is no human-induced habitat loss (the area is very lightly used for feeding for mainly camels and goats), there is no persecution by local people and the observed population structure (although of small numbers) shows a mix of mature and young animals. These facts serve to reinforce the IUCN classification of *P. spekei* being of least concern.



Figure 1. Adult *Pectinator spekei* basking on rock surface showing short bushy tail.



Figure 2. Attentive adult *Pectinator spekei* close to entrance to rock burrow.



Figure 3. Location of sighting of *Pectinator spekei* in Afar Regional State, Ethiopia: detail of area of observation; in context of Ethiopia; and, main area of previous observations.



Figure 4. Rock outcrop populated by rodents set in context of semi-desert scrub in Afar National Regional State, Ethiopia.

REFERENCES

- Aulagnier S., 2008. *Ctenodactylus gundi*. The IUCN Red List of Threatened Species, 2008: e.T5792A11701789. <https://doi.org/10.2305/IUCN.UK.2008.RLTS.T5792A11701789.en>. Downloaded on 07 December 2018.
- Brito J.C., Álvares F., Martínez-Freiría F., Sierra P., Sillero N. & Parroso P., 2010. *Ctenodactylus gundi*. Data on the distribution of mammals from Mauritania, West Africa. *Mammalia*, 74: 449–455. <https://doi.org/10.1515/MAMM.2010.055>.
- Cassola F., 2016a. *Massoutiera mzabi*. The IUCN Red List of Threatened Species, 2016: e.T12855A22191765. <https://doi.org/10.2305/IUCN.UK.2016-2.RLTS.T12855A22191765.en>. Downloaded on 13 December 2018.
- Cassola F., 2016b. *Pectinator spekei* (errata version published in 2017). The IUCN Red List of Threatened Species, 2016: e.T16458A115133455. <http://dx.doi.org/10.2305/IUCN.UK.20163.RLTS.T16458A22191688.en>. Downloaded on 27 November 2018.
- Gerrie R. & Kennerley R., 2016. *Ctenodactylus vali* (errata version published in 2017). The IUCN Red List of Threatened Species, 2016: e.T5793A115518270. <https://doi.org/10.2305/IUCN.UK.2016-3.RLTS.T5793A102029922.en>. Downloaded on 07 December 2018.
- Gerrie R., Kennerley R. & Granjon L., 2017. *Felovia vae*. The IUCN Red List of Threatened Species, 2017: e.T8548A22191482. <https://doi.org/10.2305/IUCN.UK.20172.RLTS.T8548A22191482.en>. Downloaded on 13 December 2018.
- Gouat P., Gouat J. & Coulon J., 2009. Répartition et habi-

- tat de *Massoutiera mzabi* (Rongeur Ctenodactylidé) en Algérie. *Mammalia*, 48: 351–362. <https://doi.org/10.1515/mamm.1984.48.3.351>.
- López-Antoñanzas R., 2016. Ctenodactylidae (gundis). In: Wilson D.E., Lacher Jr. T.E. & Mittermeier R.A., 2016. Handbook of the Mammals of the World, Volume 6, Lagomorphs & Rodents I., Lynx Edicions, Barcelona. 173–184.
- López-Antoñanzas R. & Knoll F., 2011. A comprehensive phylogeny of the gundis (Ctenodactylinae, Ctenodactylidae, Rodentia). *Journal of Systematic Palaeontology*, 9: 379–398. <https://doi.org/10.1080/14772019.2010.529175>.
- Pearch M.J., Bates P.J.J. & Magin C., 2002. A review of the small mammal fauna of Djibouti and the results of a recent survey, *Mammalia*, 65: 387–410. <https://doi.org/10.1515/mamm.2001.65.3.387>.
- Wilson R.T., 1977. The vegetation of central Tigré, Ethiopia, in relation to its land use. *Webbia* 32: 235–270. <https://doi.org/10.1080/00837792.1977.10670095>.
- Yalden D.W., Largen M.J. & Kock D., 1976. Catalogue of the mammals of Ethiopia, **2**. Insectivora and Rodentia. *Monitore Zoologico Italiano Supplemento*, 8: 1, 1–118. <https://doi.org/10.1080/03749444.1976.10736830>.
- Yalden D.W., Largen M.J., Kock D. & Hillman J.C., 1996. Catalogue of the Mammals of Ethiopia and Eritrea, **7**. Revised checklist, zoogeography and conservation. *Tropical Zoology*, 9: 73–164. <https://doi.org/10.1080/03946975.1996.10539304>.

First record of *Theloderma lateriticum* Bain, Nguyen et Doan, 2009 (Anura Rhacophoridae) from China with redescribed morphology

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ABSTRACT

Theloderma lateriticum Bain, Nguyen et Doan, 2009 (Anura Rhacophoridae) is recorded for the first time outside of Vietnam. The new locality record is from Shiwandashan National Nature Reserve, southern Guangxi, China, adjoining to Vietnam. We complemented and improved the morphological characters, including tadpole's morphology and advertisement calls.

KEY WORDS

Theloderma lateriticum; new national record; distribution; southern China.

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INTRODUCTION

Theloderma lateriticum Bain, Nguyen et Doan, 2009 (Anura Rhacophoridae) was described based on a single specimen (Voucher no. AMNH 168757/IEBR A. 0860, adult male). The type locality is the Hoang Lien Mountains, Lao Cai Province, northwestern Vietnam, between 1,300-1,400 meters elevation (Bain et al., 2009). Then, two new distribution records for Vietnam were reported, Yen Tu, Bac Giang (Voucher no. VNMN 1215, 1216, two adult males) and Ta Sua, Son La (Voucher no. TBUPAE 226, male; TBUPAE 227; female), respectively (Hecht et al., 2013; Nguyen et al., 2015; Pham & Nguyen, 2018). However, Nguyen et al. (2015) pointed out that Yen Tu and Ta Sua specimens present a vocal slit, but holotype lacks the vocal slit. Otherwise,

these specimens displayed high genetic variation, ranging from 0.5 to 4.9 based on combined sequences of 12S rRNA, tRNA^{Val}, and 16S rRNA yielded a total of 2412 bp positions (Nguyen et al., 2015).

In 2017, we carried out the monitoring of amphibians at Shiwandashan National Nature Reserve, Guangxi, China (21.844043° - N, 107.891647° E, 532 m asl). We found *Theloderma lateriticum* breeding in PVC buckets (diameter = 25 cm, height = 20 cm) that were used to monitor amphibians. Bain et al. (2009) have suggested that this species may also occur in neighboring southeastern Yunnan Province, China, and northeastern Laos. Herein, we reported the first record of *T. lateriticum* from China, and redescribed its morphological characters and constructed its phylogeny based on mitochondrial DNA genes fragments.

MATERIAL AND METHODS

Morphological data

All specimens were fixed in 10% formalin then stored in 75% ethanol. Before fixing in formalin, muscle tissue was collected and then stored in 100% ethanol for DNA extraction. Specimens were deposited at the Natural History Museum of Guangxi (NHMG).

Morphological measurements were taken with digital calipers to the nearest 0.1 mm. Measurements include snout-vent length (SVL); head length from tip of snout to rear of jaw (HL); head width at the commissure of the jaws (HW); snout length from tip of snout to the anterior corner of eye (SNT); diameter of the exposed portion of the eyeball (ED); interorbital distance (IOD); horizontal diameter of tympanum (TD); distance from anterior edge of tympanum to posterior corner of eye (TED); internarial space (IN); eye-nostril distance from anterior of eye to nostril (EN); tibia length with the hindlimb flexed (TIB); forelimb length from elbow to tip of the third finger (FLL); thigh length from vent to knee (THL); pes length from tip of the fourth toe to base of the inner metatarsal tubercles (PL); manus length from tip of the third digit to base of tubercle on prepollex (ML); diameter of the third finger disc (FTD3), and diameter of the fourth toe disc (HTD4). The webbing formula followed Myers & Duellman (1982). Tadpole labial tooth row formula (LTRF) followed Altig & McDiarmid (1999).

Molecular data

Genomic DNA was extracted from muscle using QIAgen DNeasy tissue extraction kits. The primers 16SAR and 16SBR of Palumbi et al. (1991) were used to amplify around 540 base pair fragment of the 16S rRNA gene, with standard PCR protocols. PCR products were directly sequenced using ABI 3730 DNA analyzer (Applied Biosystems, USA). Newly determined sequences were submitted for BLAST searching to ensure that the target fragment had been amplified (<https://blast.ncbi.nlm.nih.gov/Blast.cgi>) (Altschul et al., 1997) and deposited in GenBank (MH521262–3), then were aligned using Clustalx in MEGA 7 (Kumar et al., 2016) with the default settings. Given the close relationship be-

tween *Theloderma* and *Nyctixalus*, we included homologous DNA of two genera *Theloderma* and *Nyctixalus* downloaded from GenBank for phylogenetic analyses (Table 1). Uncorrected pairwise genetic variation was calculated in MEGA 7 using a ~530 bp mtDNA 16S fragment. The Akaike Information Criterion (AIC) implemented in MrModeltest 2.3 (Nylander, 2004) was used to identify the best-fitting models of DNA substitution for our data. Bayesian inference (BI) method was used to reconstruct phylogenetic relationships and carried out using MrBayes 3.12 (Ronquist & Huelsenbeck, 2003). Four independent Markov Chain Monte Carlo searches were run for 20 million generations, sampled every 1000 generations, each with four chains and default priors. A 50% majority-rule consensus tree was constructed to calculate the Bayesian posterior probabilities (BPP) of the tree nodes.

Bioacoustics analysis

The advertisement calls were recorded with an ICD recorder (Sony ICD-TX50) at a distance of approximately 0.2–0.3 m. Ambient temperature was taken with a TP-2200 (A-volt). Calls were analyzed with Raven Pro 1.5 software (<http://www.birds.cornell.edu/brp/raven/RavenOverview.html>) with default setting.

RESULTS

Systematics

Classis AMPHIBIA Linnaeus, 1758

Ordo ANURA Hogg, 1839

Familia RHACOPHORIDAE Hoffman, 1932

Genus *Theloderma* Tschudi, 1838

Theloderma lateriticum Bain, Nguyen et Doan, 2009

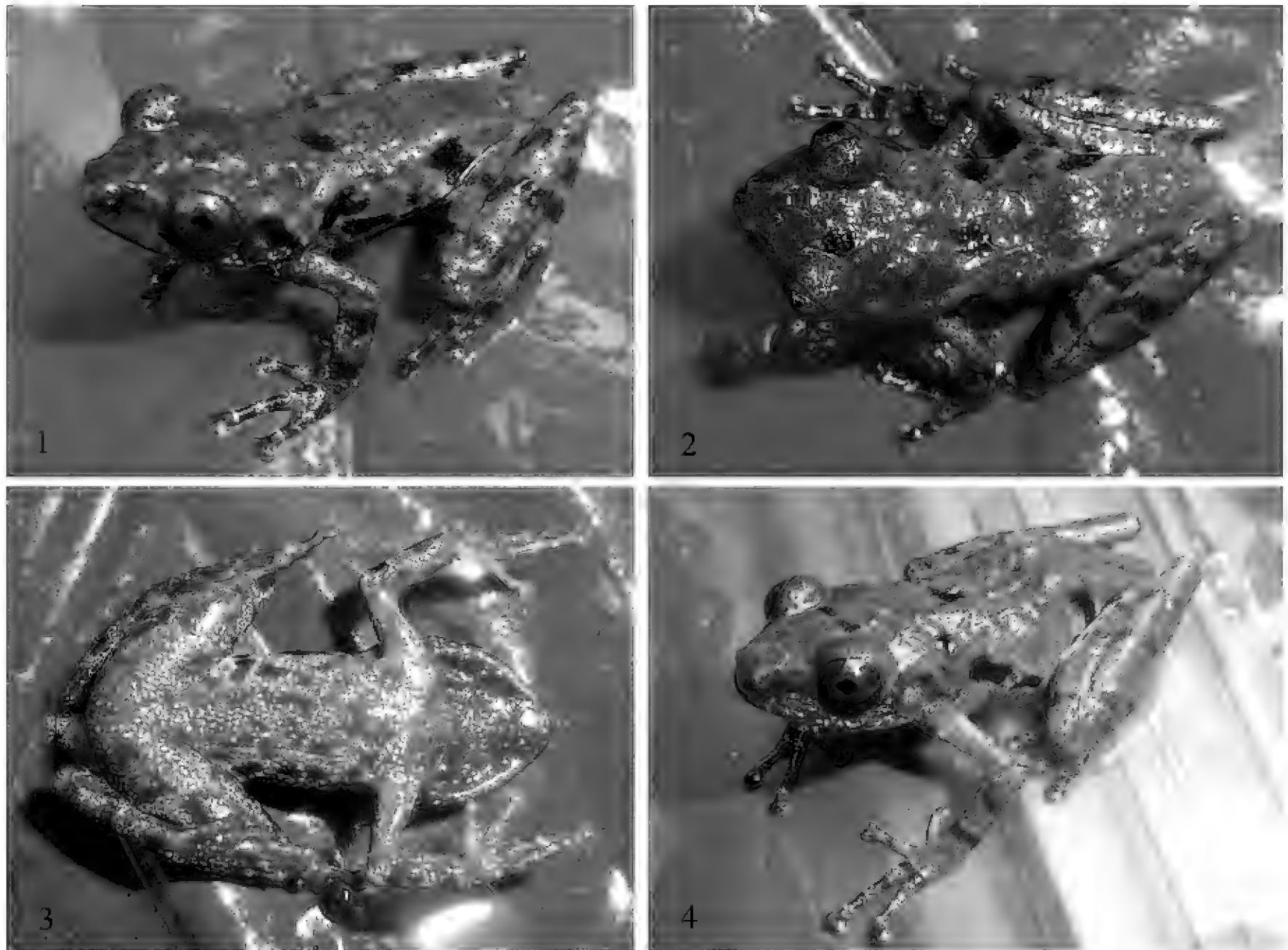
EXAMINED MATERIAL. NHMG1704001, NHMG1706010–11, adult males, and NHMG1706012, adult female from Shiwandashan National Nature Reserve, Guangxi, China (21.844123° N, 107.891561° E, 510 m asl), collected by Weicai Chen, Yunming Mo, and Shichu Zhou on 21 April and 24 June, 2017.

DESCRIPTION. Habitus slender. Head wider than long ($HL/HW = 0.83$). Snout slightly subacuminate in dorsal view, rounded in lateral view, and projecting beyond lower jaw; nostril oval, oblique, much closer to tip of snout than to eye, internarial shorter than interorbital distance ($IN/IOD = 0.83$); canthus rostralis distinct, rounded; lores oblique, concave; interorbital region slightly concave, interorbital distance longer than upper eyelid width ($IOD/UEW = 1.43$); pupil diamond-shaped, horizontal; eye diameter shorter than snout length ($ED/SNT = 0.86$); tympanum distinct, rounded, 58% of eye diameter, tympanic rim elevated relative to skin of temporal region; dorsolateral folds absent; pineal ocellus absent; vomerine teeth absent; choanae oval, at margins of roof of mouth; tongue elongated-cordiform, attached anteriorly, deeply notched posteriorly; supratympanic fold from posterior margin of eye to level slightly posterior to axilla; vocal sac absent (Figs. 1–4, Table 2).

Forelimb slender. Finger tips with well-expanded discs having distinctly circummarginal grooves, finger III disc width 62% tympanum diameter; relative finger lengths $I < II < IV < III$; fingers without webbing; subarticular tubercles distinct, surfaces rounded, formula 1, 1, 2, 2; accessory palmar tubercles indistinct; nuptial pad present, elongated, covering prepollex area (Figs. 5, 6).

Hindlimb slender. Toe tips with distinctly expanded discs with circummarginal grooves, diameter of discs slightly shorter than those of fingers; toes slender; relative toe lengths $I < II < III \leq V < IV$; toes moderately webbed, webbing formula: $I 1 - 1 - II 1 + - 1 - III 1 + - 1 + IV 1 + - 2 - V$; subarticular tubercles rounded, distinct, formula 1, 1, 2, 3, 2; inner metatarsal tubercle oval, elongated; outer metatarsal tubercle and supernumerary tubercle absent (Figs. 5, 6).

Smooth dorsal skin without distinct skin ridge, but dorsal surfaces of head, back, limbs and outer



Figures 1–4. Dorsolateral (Fig. 1), dorsal (Fig. 2) and ventral view (Fig. 3) of NHMG1704001 (adult male) 241 in life, and (Fig. 4) dorsolateral view of NHMG1706012 (female) in life.

margin of foot are interspersed with some asperities; coarsely granular venter; absent dermal fringe and velvety and ovoid nuptial pad on prepollex area.

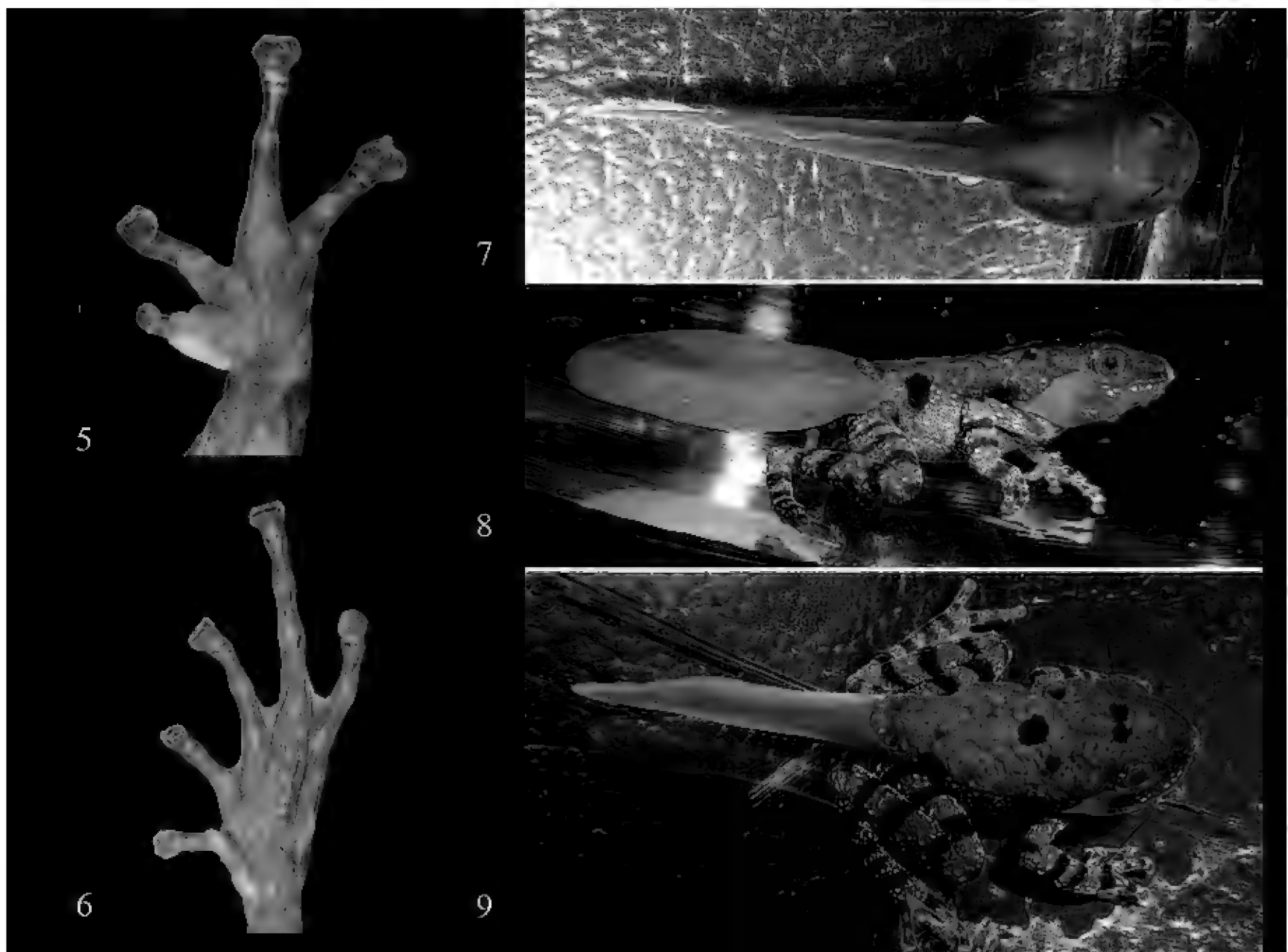
Color in life. Tip of snout, loreal region, upper eyelids, supratympanic fold and shoulder are brick-red; dorsum has several irregular brown markings; brown upper lip contains several white spots; flanks are brown with black blotches, and the lower portion of flanks exhibits white spots; grey-brown forelimbs with two dark brown transverse bands; brown hindlimbs with three dark brown transverse bands; grey digit tips with white spots; grey-brown venter with white spots; dark brown pupils and brick-red iris with deeply red ring along the margin (Figs. 1–4).

Color in preservative. Brown body with dark brown markings. Brown ventral surface with grey spots. Brick-red faded on the tip of snout, loreal region, upper eyelids, supratympanic fold and shoulder.

Tadpole. Tadpoles were assigned to the new

species because the color pattern resembled that of adults (Figs. 7–9). Tadpoles exhibit a rounded and depressed body shape; dorsal eyes and nares; nares are nearer to the snout than eyes; medial vent tube; sinistral spiracle; broadly rounded tail tip. The oral apparatus is anteroventral. The labial tooth row formula (LTRF) is $3(2-3)/3$ ($n = 4$, stage 32–38). The marginal papillae have a large dorsal gap and lack a medial gap on the lower labium. The body is dark brown, and the tail fin is pale brown. Measurements (in mm) of four tadpoles at developmental stages 32–38 (Gosner, 1960) are as follows: total length, 26.0–28.7 mm; body length, 10.1–10.7 mm; maximum tail height, 5.6–6.8 mm; tail muscle height, 3.1–3.8 mm; interorbital distance, 2.8–3.2 mm; internarial distance, 1.6–2.1 mm; oral disk width, 2.2–2.5 mm and oral disk height, 0.8–0.9 mm.

MOLECULAR ANALYSES. Our preliminary phylogenetic trees were similar to Poyarkov et al. (2018),



Figures 5, 6. Ventral view of the hand (Fig. 5), and of the foot (Fig. 6) of NHMG1704001. Figures 7–9. Tadpole of *Theloderma lateriticum*. Dorsal view of tadpole (Fig. 7), lateral view (Fig. 8), and dorsal view of metamorphs (Fig. 9).

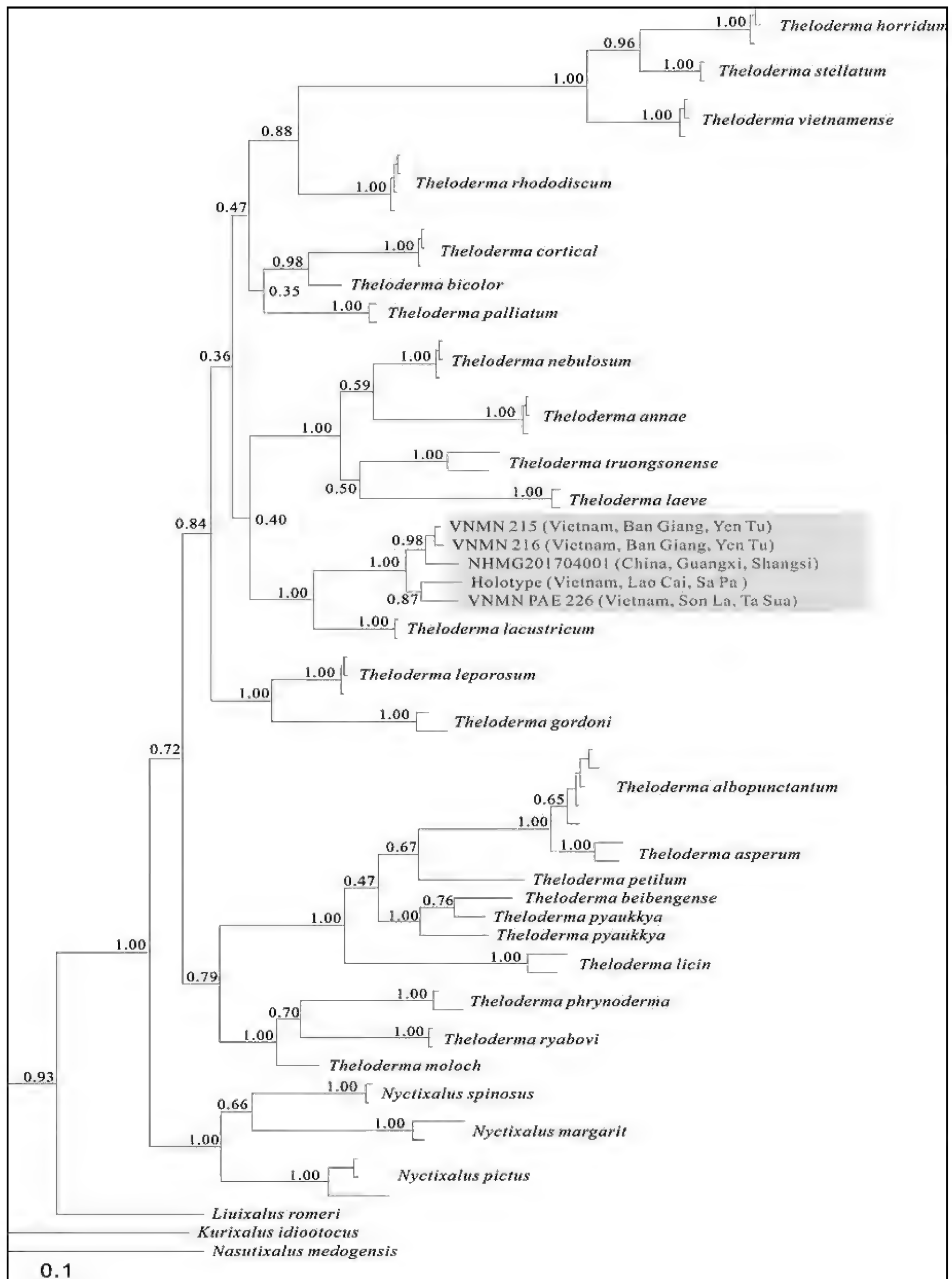


Figure 10. Bayesian inference tree reconstructed from 16S rRNA mitochondrial gene with *Kurixalus idiotocus*, *Liuxalus romeri*, and *Nasutixalus medogensis* as outgroups. Numbers above branches represent bootstrap supports for Bayesian posterior probabilities (BPP).

ID	Species	Voucher no.	Locality	GenBank no.	Reference
1	<i>Nyctixalus pictus</i>	FMNH 231095	Malaysia,Sabah, Lahad Datu	DQ283133	Frost et al., 2006
2	<i>N. pictus</i>	FMNH 231094	Malaysia	AF458135	Wilkinson et al., 2002
3	<i>N. pictus</i>	AH07001	Malaysia,Sarawak, Gunung Mulu	GU154888	Das and Haas, 2010
4	<i>N. spinosus</i>	ACD 1043	Philippine Islands, Mindanao	DQ283114	Frost et al., 2006
5	<i>N. spinosus</i>	pet trade	Philippine Islands, Mindanao	KT461916	Poyarkov et al., 2015
6	<i>N. margaritifer</i>	TNHCJAM 3030	Indonesia, Java	EU178087	Biju et al., 2008
7	<i>N. margaritifer</i>	KUHE 26135	Indonesia, Java	LC012864	Dever, 2017
8	<i>T. albopunctatum</i>	KIZ 060821217	China, Guangxi, Jinxiu	EF564522	Yu et al., 2008
9	<i>T. albopunctatum</i>	HN0806100	China, Hainan	GQ285678	Dever, 2017
10	<i>T. albopunctatum</i>	VNMN J2916	Vietnam, Vinh Phuc	KJ802913	Dever, 2017
11	<i>T. albopunctatum</i>	NHMG20160632	China, Guangxi, Shangsi	MH521263	This study
12	<i>T. annae</i>	IEBR3732	Vietnam, Hoa Binh	LC168170	Nguyen et al., 2016
13	<i>T. annae</i>	IEBR3733	Vietnam, Hoa Binh	LC168171	Nguyen et al., 2016
14	<i>T. annae</i>	IEBR3734	Vietnam, Hoa Binh	LC168172	Nguyen et al., 2016
15	<i>T. asperum</i>	VNMN J 2888	Vietnam, Tam Dao, Vin Phu	LC012853	Li et al., 2016
16	<i>T. asperum</i>	VNMN 4404	Vietnam, Ngoc Linh, Kon Tum	LC012854	Li et al., 2016
17	<i>T. asperum</i>	VNMN 4405	Vietnam, Kon Ka Kinh, Gia Lai	LC012855	Li et al., 2016
18	<i>T. baibungense</i>	YPX31940	China, Medog, Tibet	KU981089	Li et al., 2016
19	<i>T. bicolor</i>	IEBR A. 2011.4	Vietnam, Lao Cai, Sa Pa	JX046474	Gawor et al., 2012
20	<i>T. corticale</i>	AMNH A 161499	Vietnam, Dao, Vin Phu	DQ283050	Li et al., 2016
21	<i>T. corticale</i>	VNMN 3556	Vietnam, Tam Dao,	LC012841	Li et al., 2016
22	<i>T. corticale</i>	NHMG20161003	China, Guangxi, Shangsi	MG322125	Chen et al., 2018
23	<i>T. gordonii</i>	VNMN 03013	Vietnam,Nghe An	JN688167	Rowley et al., 2011
24	<i>T. gordonii</i>	VNMN PAE217	Vietnam,Son La	KJ802918	Nguyen et al., 2014
25	<i>T. horridum</i>	LJT W44	Malaysia	KC465843	Li et al., 2013
26	<i>T. horridum</i>	LJT W45	Malaysia	KC465842	Li et al., 2013
27	<i>T. horridum</i>	ZMMU NAP-04015	Thailand,Satun	KT461890	Poyarkov et al., 2015
28	<i>T. lacustrinum</i>	NCSM84682	Laos,Vientiane Province,Feuang District	KX095245	Sivongxay et al., 2016
29	<i>T. lacustrinum</i>	NCSM84683	Laos,Vientiane Province,Feuang District	KX095246	Sivongxay et al., 2016
30	<i>T. laevis</i>	ZMMU NAP-01645	Vietnam Lam Dong, Cat Loc	KT461913	Poyarkov et al., 2015

Table 1/1. Samples and sequences used in this study. Generic allocation according to Frost (2017).

ID	Species	Voucher no.	Locality	GenBank no.	Reference
31	<i>T. laeve</i>	ZMMU NAP-02906 AMNH	Vietnam Binh Phuoc, Bu Gia Map	KT461883	Poyarkov et al., 2015
32	<i>T. lateriticum</i>	168757/IEBR A. 0860	Vietnam, Lao Cai, SaPa	LC012848	Nguyen et al., 2015
33	<i>T. lateriticum</i>	VNMN PAE 226	Vietnam, Son La, Ta Sua	LC012849	Nguyen et al., 2015
34	<i>T. lateriticum</i>	VNMN 215	Vietnam, Ban Giang, Yen Tu	LC012850	Nguyen et al., 2015
35	<i>T. lateriticum</i>	VNMN 216	Vietnam, Ban Giang, Yen Tu	LC012851	Nguyen et al., 2015
36	<i>T. lateriticum</i>	NHMG201704001	China, Guangxi, Shangsi	MH521262	This study
37	<i>T. leporosum</i>	LJT W46	Malaysia	KC465841	Li et al., 2013
38	<i>T. leporosum</i>	leporosum-1	Malaysia, Selangor	KT461922	Poyarkov et al., 2015
39	<i>T. leporosum</i>	KUHE 52581	Malaysia, Negeri Sembilan	AB847128	Nguyen et al., 2014
40	<i>T. licin</i>	KUHE 19426	Tailand, Nakon Sri Tamarat	LC012859	Li et al., 2016
41	<i>T. licin</i>	KUHE 52599	Malaysia, Selangor	KJ802920	Nguyen et al., 2014
42	<i>T. moloch</i>	SDBDU 2011.345	Arunachal Pradesh, India	KU169993	Biju et al., 2016
43	<i>T. nebulosum</i>	ROM 39588	Vietnam, Kon Tum, Ngoc Linh	KT461887	Poyarkov et al., 2015
44	<i>T. nebulosum</i>	AMS R 173409	Vietnam, Kon Tum, Ngoc Linh	JN688168	Rowley et al., 2011
45	<i>T. nebulosum</i>	AMS R 173877	Vietnam, Kon Tum, Ngoc Linh	JN688169	Rowley et al., 2011
46	<i>T. palliatum</i>	AMS R 173130	Vietnam Lam Dong, Bi Doup-Nui Ba	JN688172	Rowley et al., 2011
47	<i>T. palliatum</i>	ZMMU NAP-01846	Vietnam Lam Dong, Bi Doup-Nui Ba	KT461901	Poyarkov et al., 2015
48	<i>T. petihum</i>	HNUE MNA.2012.0001	Vietnam Dien Bien, Muong Nhe	KJ802925	Nguyen et al., 2014
49	<i>T. phrynoderma</i>	CAS 243920	Myanmar, Tanintharyi	KJ128282	Dever, 2017
50	<i>T. phrynoderma</i>	CAS 247910	Myanmar, Tanintharyi	KJ128283	Dever, 2017
51	<i>T. pyaukkya</i>	CAS 236133	Myanmar, Kachin	KU244360	Dever, 2017
52	<i>T. pyaukkya</i>	CAS 234869	Myanmar, Chin	KU244370	Dever, 2017
53	<i>T. rhododiscum</i>	KIZ060821063	China, Guangxi, Jinxiu	EF564533	Yu et al., 2008
54	<i>T. rhododiscum</i>	KIZ060821170	China, Guangxi, Jinxiu	EF564534	Yu et al., 2008
55	<i>T. rhododiscum</i>	SCUM 061102L	China, Guangxi, Jinxiu	EU215530	Li et al., 2008
56	<i>T. rhododiscum</i>	CIB GX200807048	China, Guangxi, Jinxiu	KJ802921	Nguyen et al., 2014
57	<i>T. ryabovi</i>	ryabovi-1	Vietnam Kon Tum, Kon Plong, Mang Canh	KT461914	Poyarkov et al., 2015

Table 1/2. Samples and sequences used in this study. Generic allocation according to Frost (2017).

ID	Species	Voucher no.	Locality	GenBank no.	Reference
58	<i>T. ryabovi</i>	ryabovi-2	Vietnam Kon Tum, Kon Plong, Mang Canh	KT461915	Poyarkov et al., 2015
59	<i>T. stellatum</i>	stellatum-1	Thailand Chanthaburi, Phliu	KT461918	Poyarkov et al., 2015
60	<i>T. stellatum</i>	ZMMU NAP-03961	Thailand Nakhon Nayok, Nang Rong	KT461917	Poyarkov et al., 2015
61	<i>T. truongsongense</i>	ROM 39363	Vietnam Khanh Hoa, Hon Ba	KT461925	Poyarkov et al., 2015
62	<i>T. truongsongense</i>	AMS R 171510	Vietnam Quang Nam	JN688174	Rowley et al., 2011
63	<i>T. vietnamense</i>	ZMMU NAP-00707	Vietnam Dong Nai, Nam Cat Tien	KT461889	Poyarkov et al., 2015
64	<i>T. vietnamense</i>	ZMMU NAP-03680	Vietnam Tay Ninh, Lo Go-Xa Mat	KT461921	Poyarkov et al., 2015
65	<i>T. vietnamense</i>	ZMMU NAP-03723	Vietnam Kien Giang, Phu Quoc	KT461919	Poyarkov et al., 2015
66	<i>Nasutixalus medogensis</i>	6255Rao	China, Motuo, Xizang	GQ285679	Jiang et al., 2016
67	<i>Liuixalus romeri</i>	CIB20080048	China, Hong Kong	AB871412	Nguyen et al., 2014
68	<i>Kurixalus idiootocus</i>	SCUM 061107L	China, Taiwan, Lianhuachi	EU215547	Li et al., 2008

Table 1/3. Samples and sequences used in this study. Generic allocation according to Frost (2017).

Character	Male NHMG1704001	Male NHMG1706010	Male NHMG1706011	Female NHMG1706012
SVL	24.6	23.8	23.3	24.8
HL	7.7	7.2	6.6	8.2
HW	9.3	8.3	8.2	9.3
SNT	4.2	3.9	3.8	4.1
ED	3.6	3.0	3.1	3.6
IOD	3.0	2.9	3.1	3.5
TD	2.1	1.9	2.0	1.8
UEW	2.1	1.9	2.2	2.4
TED	0.3	0.6	0.6	0.6
IN	2.5	2.2	2.2	2.7
EN	2.0	2.2	2.1	2.7
TIB	12.7	12.8	12.0	13.4
FLL	11.8	11.5	10.9	13.2
THL	13.3	13.1	12.9	13.8
PL	10.3	10.0	9.3	10.8
ML	7.3	6.8	6.2	7.0
FTD ₃	1.3	1.5	1.3	1.2
HTD ₄	1.2	1.3	1.2	1.1

Table 2. Measurements (mm) of *Theloderma lateriticum*. Abbreviations defined in text.

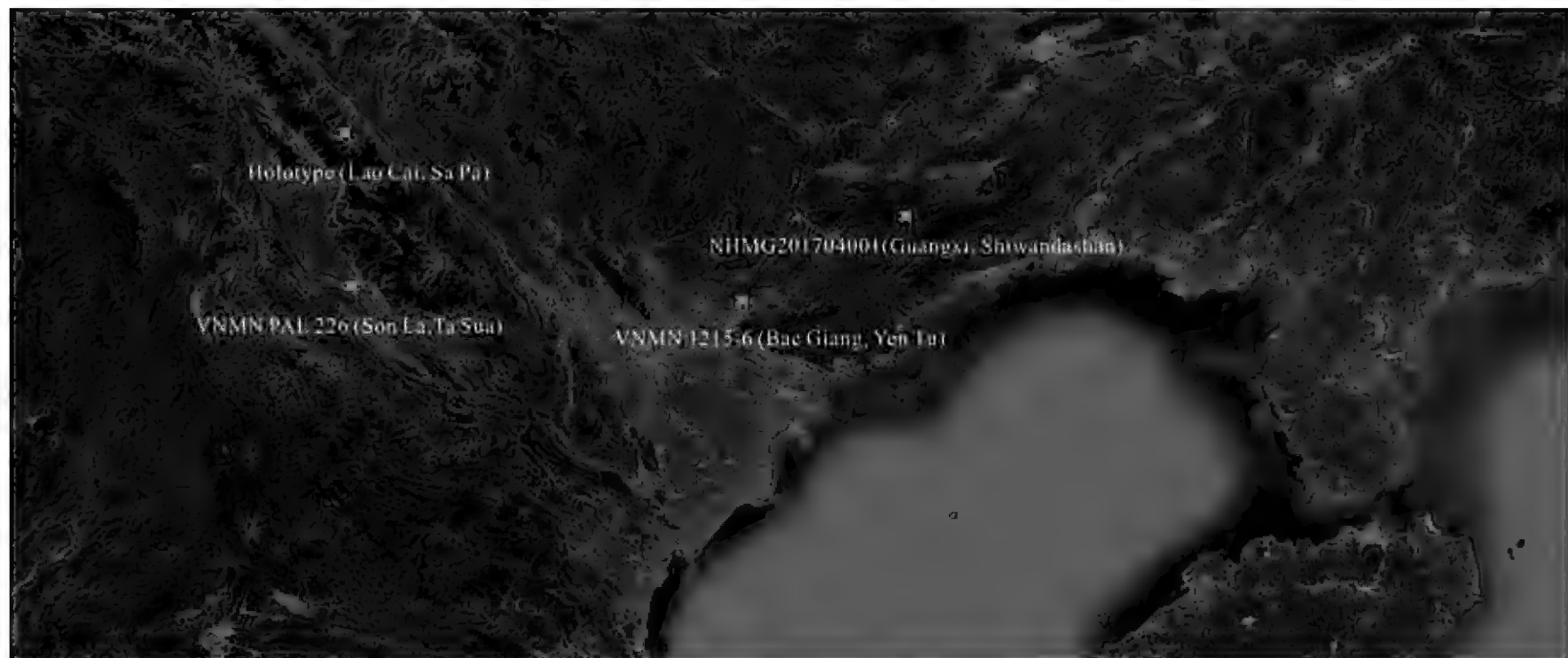
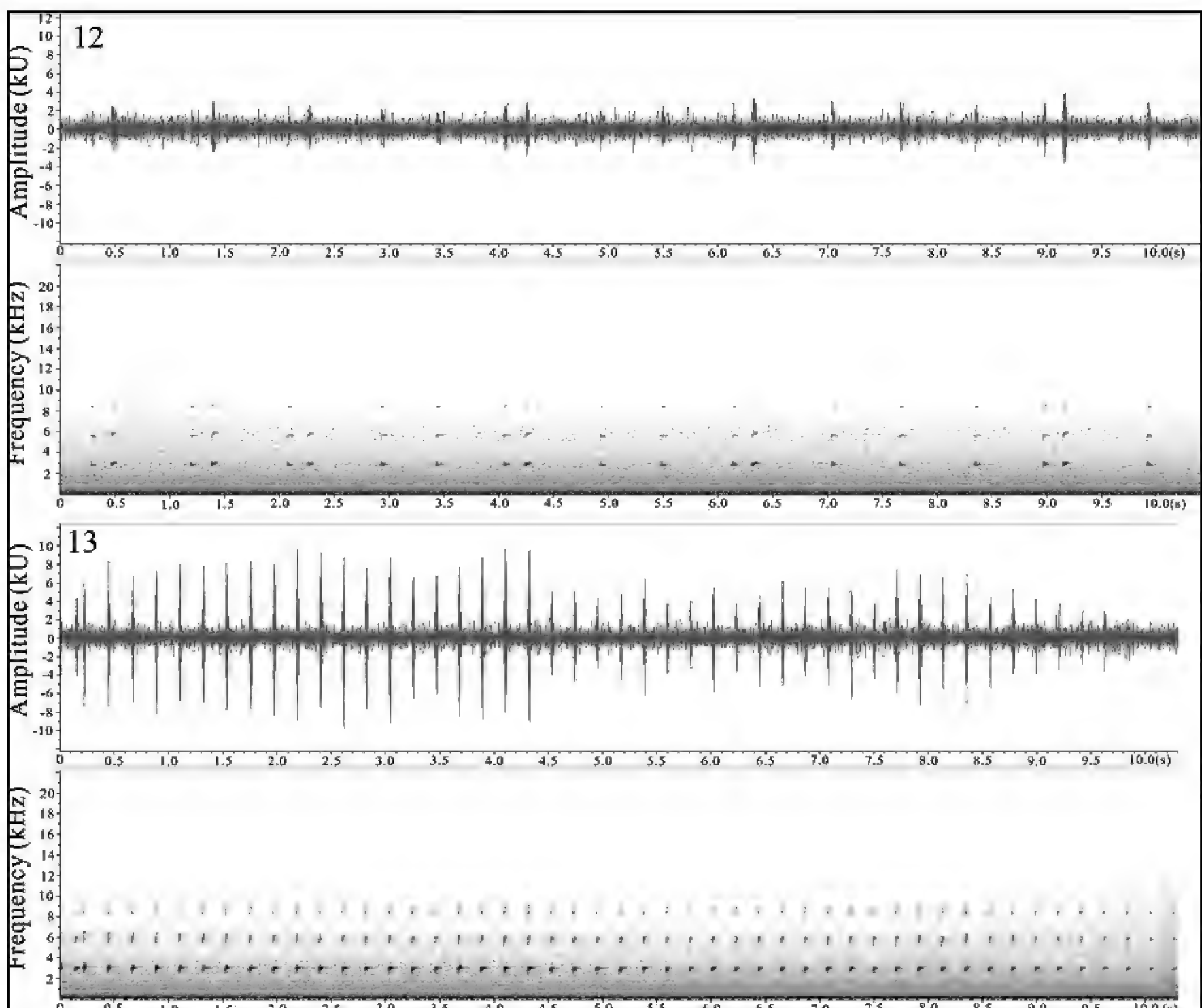


Figure 11. Distribution of *Theloderma lateriticum*.



Figures 12, 13. Two types of advertisement calls of *Theloderma lateriticum* recorded at ambient temperature of 21°C. Figure 12 and figure 13 showed variable durations between calls.

	1	2	3	4
Holotype (Lao Cai, Sa Pa)				
VNMN PAE 226 (Son La, Ta Sua)	4.1			
VNMN 1215 (Bac Giang, Yen Tu)	4.3	3.9		
VNMN 1216 (Bac Giang, Yen Tu)	4.1	3.7	0.6	
NHMG201704001 (Guangxi, Shiwandashan)	4.4	4.3	2.4	2.2

Table 3. Uncorrected p-distances (in %) in *Theloderma lateriticum* group based on mitochondrial 16S rRNA sequences (~530 bp).

Nguyen et al. (2015) and Huang et al. (2017) (Fig. 10). All *T. lateriticum* specimens form a monophyletic group. Holotype is closer to Ta Sua specimen than Yen Tu and Shiwandashan specimens, matching their geographical distance (Fig. 11). Uncorrected sequence divergences at the 16S rRNA gene between type locality and other three sites range from 4.1–4.4% (Table 3), but Shiwandashan specimens and Yen Tu specimens range from 2.2–2.4% (Table 3). Genetic variation between *T. lateriticum* and all available homologous 16S rRNA sequences is great than 8.5%.

Advertisement call. We only recorded the calls of a single male (Voucher no. NHMG1704001) near PVC buckets at an ambient temperature of 21°C. We detected two typical calls, but these calls have the same dominant frequency and harmonics (Fig. 12, 13). The dominant frequency ranges from 2.5–3.5 kHz, and harmonics present at 5.8–6.8 kHz and 8.0–9.0 kHz. Figures 13, 13 showed waveforms and corresponding spectrograms for 10 s. For figure 12, the durations between calls are variable, ranging from 200–700 ms; for figure 13, the durations are relatively stable, presenting around 220 ms.

DISCUSSION

Morphologically, Shiwandashan, Yen Tu and Ta Sua specimens are similar to holotype. Nguyen et al. (2015) were convinced that Yen Tu and Ta Sua specimens had a vocal slit, but they lacked a vocal slit in holotype as well as our specimens. For color model, our specimens are more similar to Ta Sua specimens than Yen Tu specimens and holotype (Hecht et al., 2013; Pham & Nguyen, 2018). Toe

webs also display subtle differences, webbing formula: I 1- – 1- II 1+ – 1- III 1+ – 1+ IV 1+ – 2- V in our specimens vs. I1½ – 2II1½ – 2III1 – 2½IV2½ – 2V in Ta Sua specimens. For the skin texture, holotype and Yen Tu specimens are granular, but Shiwandashan and Ta Sua specimens are obviously smooth (Hecht et al., 2013; Pham & Nguyen, 2018). Holotype was collected on 10 September, but other specimens were collected in April or June. In Shiwandashan, we found that the breeding season of *T. lateriticum* ranges from April to June. Whether some morphological differences are caused by the breeding season and non-breeding season need further investigation.

Genetic variations between holotype and other specimens range from 4.1% to 4.4% based on the part of 16S rRNA (~530 bp); genetic variations greater than 3% represents differentiation at the species level in frogs (Vences et al., 2005). However, genetic variation between our specimens and Yen Tu specimens is about 2.2%. Other examples of high intraspecific genetic variation included *T. albopunctatum* (2.5%), *T. gordonii* (2.1–4.6%), *T. licin* (3.8%), *T. pyaukkya* (3.9%), *T. truongsongense* (3.8%) and *T. stellatum* (0.4–3.0%) (Nguyen et al., 2015; Pham & Nguyen, 2018). High genetic variation indicated the possible presence of cryptic species in these group. For *T. lateriticum* group, because *T. lateriticum* was described based on a single specimen and lacked variation data, we consider these specimens as a single species despite presence of subtle morphological variations and relative high genetic variation. If we want to determine the *T. lateriticum* species complex, it is necessary to collect more specimens from type locality.

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REFERENCES

- Altig R. & McDiarmid R.W., 1999. Body plan: development and morphology. In: McDiarmid, R.W. & Altig R. (Eds.), *Tadpoles: the biology of anuran larvae*. The University of Chicago Press, Chicago, pp. 24–51.
- Altschul S.F., Madden T.L., Schäffer A.A., Zhang J., Zhang Z., Miller W. & Lipman D.J., 1997. Gapped BLAST and PSI-BLAST: a new generation of protein database search programs. *Nucleic Acids Research*, 25: 3389–3402. <https://doi.org/10.1093/nar/25.17.3389>
- Bain R.H., Nguyen T.Q. & Doan K.V., 2009. A new species of the genus *Theloderma* Tschudi, 1838 (Anura: Rhacophoridae) from northwestern Vietnam. *Zootaxa*, 2191: 58–68.
- Biju S.D., Roelants K. & Bossuyt F., 2008. Phylogenetic position of the montane treefrog *Polypedates variabilis* Jerdon, 1853 (Anura: Rhacophoridae), and description of a related species. *Organisms Diversity and Evolution*, 8: 267–276. <https://doi.org/10.1016/j.ode.2007.11.004>
- Biju S., Senevirathne D., Garg G., Mahony S., Kamei S., Thomas R.G., Shouche A., Raxworthy Y., Mee-gaskumbura C.J. & Van Bocxlaer M., 2016. *Frankixalus*, a new rhacophorid genus of tree hole breeding frogs with oophagous tadpoles. *PLoS ONE*, 11: e0145727. <https://doi.org/10.1371/journal.pone.0145727>
- Chen W., Liao X., Zhou S., Mo Y. & Huang Y., 2018. Rediscovery of *Rhacophorus yaoshanensis* and *Theloderma kwangsiensis* at their type localities after five decades. *Zootaxa*, 4379: 484–496. <http://dx.doi.org/10.11646/zootaxa.4379.4.2>
- Das I. & Haas A., 2010. New species of *Microhyla* from Sarawak: Old World's smallest frogs crawl out of a miniature pitcher plants on Borneo (Amphibia: Anura: Microhylidae). *Zootaxa*, 1571: 37–52. <http://dx.doi.org/10.11646/zootaxa.2571.1.2>
- Dever J.A., 2017. A new cryptic species of the *Theloderma asperum* complex (Anura: Rhacophoridae) from Myanmar. *Journal of Herpetology*, 51: 425–436. <https://doi.org/10.1670/17-026>
- Frost D.R., Grant T., Faivovich J.N., Bain R.H., Haas A., Haddad C.F.B., de Sá R.O., Channing A., Wilkinson M., Donnellan S.C., Raxworthy C.J., Campbell J.A., Blotto B.L., Moler P., Drewes R.C., Nussbaum R.A., Lynch J.D., Green D.M. & Wheeler W.C., 2006. The amphibian tree of life. *Bulletin of the American Museum of Natural History*, 297: 1–370.
- Gawor A., Chapuis S., Pham T.C., Nguyen T.Q., Schmitz A. & Ziegler T., 2012. Larval morphology of two species of the genus *Theloderma* (Tschudi, 1838) from Vietnam (Anura: Rhacophoridae: Rhacophorinae). *Zootaxa*, 3395: 59–64.
- Gosner K.L., 1960. A simple table for staging anuran embryos and larvae with notes on identification. *Herpetologica*, 16: 183–190. <https://www.jstor.org/stable/3890061>
- Hecht V.L., Pham C.T., Nguyen T.T., Nguyen T.Q., Bonkowski M. & Ziegler T., 2013. First report on the herpetofauna of Tay Yen Tu Nature Reserve, northeastern Vietnam. *Biodiversity Journal*, 4: 507–552.
- Huang H., Chen Z., Wei Z., Bu R. & Wu Z., 2017. DNA barcoding revises a misidentification on mossy frog: new record and distribution extension of *Theloderma corticale* Boulenger, 1903 (Amphibia: Anura: Rhacophoridae). *Mitochondrial DNA Part A*: 1–8. <https://doi.org/10.1080/24701394.2016.1275601>
- Jiang K., Yan F., Wang K., Zou D., Li C. & Che J., 2016. A new genus and species of treefrog from Medog, southeastern Tibet, China (Anura, Rhacophoridae). *Zoological Research*, 37: 15–20. <https://doi.org/10.13918/j.issn.2095-8137.2016.1.15>
- Yu G., Rao D., Yang J. & Zhang M., 2008. Phylogenetic relationships among Rhacophorinae (Rhacophoridae, Anura, Amphibia): with an emphasis on the Chinese species. *Zoological Journal of the Linnean Society*, 153: 733–749. <https://doi.org/10.1111/j.1096-3642.2008.00404.x>
- Kumar S., Stecher G. & Tamura K., 2016. MEGA7: Molecular Evolutionary Genetics Analysis version 7.0 for bigger datasets. *Molecular Biology and Evolution*, 33: 1870–1874. <https://doi.org/10.1093/molbev/msw054>
- Li J.T., Che J., Bain R.H., Zhao E.M. & Zhang Y.P., 2008. Molecular phylogeny of Rhacophoridae (Anura): A framework of taxonomic reassignment of species within the genera *Aquixalus*, *Chiromantis*, *Rhacophorus*, and *Philautus*. *Molecular Phylogenetics and Evolution*, 48: 302–312. <https://doi.org/10.1016/j.ympev.2008.03.023>
- Li J.T., Li Y., Klaus S., Rao D.Q., Hillis D.M. & Zhang Y.P., 2013. Diversification of rhacophorid frogs provides evidence for accelerated faunal exchange between India and Eurasia during the Oligocene. *Proceedings of the National Academy of Sciences of the United States of America*, 110: 3441–3446. <https://doi.org/10.1073/pnas.1300881110>

Li C., Hou M., Yu G.H., Yan F., Li B.Z., Jiang K., Li P.P. & Orlov N.L., 2016. Rediscovery of *Theloderma moloch* (Amphibian: Anura: Rhacophoridae) from south-east Tibet, China after 102 years. *Russian Journal of Herpetology*, 23: 41–54.

Myers C.W. & Duellman W.E., 1982. A new species of *Hyla* from Cerro Colorado and other tree frog records and geographical notes from western Panama. *American Museum Novitates*, 275: 32.

Nguyen T.T., Le D.T., Nguyen S.H.L., Matsui M. & Nguyen T.Q., 2014. First record of *Philautus petilus* Stuart and Heatwole, 2004 (Amphibian: Anura: Rhacophoridae) from Vietnam and its phylogenetic position. *Current Herpetology*, 33: 112–120. <https://doi.org/10.5358/hsj.33.112>

Nguyen T.T., Matsui M. & Eto K., 2015. Mitochondrial phylogeny of an Asian tree frog genus *Theloderma* (Anura: Rhacophoridae). *Molecular Phylogenetics and Evolution*, 85: 59–67. <https://doi.org/10.1016/j.ympev.2015.02.003>

Nguyen T.Q., Pham C.T., Nguyen T.T., Ngo H.N. & Ziegler T., 2016. A new species of *Theloderma* (Amphibia: Anura: Rhacophoridae) from Vietnam. *Zootaxa*, 4168: 171–186. <http://dx.doi.org/10.11646/zootaxa.4168.1.10>

Nylander J.A.A., 2004. MrModeltestv2. Program Distributed by the Author. Evolutionary Biology Centre, Uppsala University.

Palumbi S.R., Martin A., Romano S., McMillan W.O., Stice L. & Grabowski G., 1991. The simple fool's guide to PCR. Department of Zoology, University of Hawaii, Honolulu, 47 pp.

Pham V.A. & Nguyen Q.T., 2018. Diversity of the genus *Theloderma* (Amphibia: Anura: Rhacophoridae) from Son La Province. *VNU Journal of Science: Natural Sciences and Technology*, 34: 48–54. http://repository.vnu.edu.vn/handle/VNU_123/61629

Poyarkov N.A.Jr., Orlov N.L., Moiseeva A.V., Pawangkhanant P., Ruangsawan T., Vassilieva A.B. & Gogoleva S.S., 2015. Sorting out moss frogs: mtDNA data on taxonomic diversity and phylogenetic relationships of the Indochinese species of the genus *Theloderma* (Anura, Rhacophoridae). *Russian Journal of Herpetology*, 22: 241–280.

Poyarkov N.A. Jr., Kropachev I.I., Gogoleva S.I. & Orlov N.L., 2018. A new species of the genus *Theloderma* Tschudi, 1838 (Amphibia: Anura: Rhacophoridae) from Tay Nguyen Plateau, central Vietnam. *Zoological Research*, 39: 156–180. <https://doi.org/10.24272/j.issn.2095-8137.2018.018>

Ronquist F.R. & Huelsenbeck J.P., 2003. MrBayes 3: Bayesian phylogenetic inference under mixed models. *Bioinformatics*, 19: 1572–1574. <https://doi.org/10.1093/bioinformatics/btg180>

Rowley J.J.L., Le D.T.T., Hoang H.D., Dau V.Q. & Cao T.T., 2011. Two new species of *Theloderma* (Anura: Rhacophoridae) from Vietnam. *Zootaxa*, 3098: 1–20.

Sivongxay N., Davankham M., Phimmachak S., Phoumixay K. & Stuart B.L., 2016. A new small-sized *Theloderma* (Anura: Rhacophoridae) from Laos. *Zootaxa*, 4147: 433–442. <http://dx.doi.org/10.11646/zootaxa.4147.4.5>

Vences M., Thomas M., Bonett R.M. & Vieites D.R., 2005. Deciphering amphibian diversity through DNA barcoding: chances and challenges. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 360: 1859–1868. <https://doi.org/10.1098/rstb.2005.1717>

Wilkinson J.A., Drewes R.C. & Tatum O.L., 2002. A molecular phylogenetic analysis of the family Rhacophoridae with an emphasis on the Asian and African genera. *Molecular Phylogenetics and Evolution*, 24: 265–273. [https://doi.org/10.1016/S1055-7903\(02\)00212-9](https://doi.org/10.1016/S1055-7903(02)00212-9)

A preliminary checklist of vascular plants of Mt. Arayat National Park, Pampanga, Philippines

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ABSTRACT

The Mt. Arayat National Park (MANP) is one of the oldest national parks and protected areas in the Philippines. However, very few published studies have been carried out despite its speculated high potential of biodiversity. Therefore, this paper intends to provide a preliminary checklist of vascular plants in MANP with emphasis on their conservation status. Several floristic surveys were conducted in the South and North peaks of MANP. A total of 98 species belonging to 92 genera and 43 families were identified. Of them, Leguminosae was the largest family which contributed 10 species, followed by Euphorbiaceae and Moraceae with 7 species each. The most dominated genera were: *Ficus* with 3 species, and *Artocarpus*, *Litsea*, and *Macaranga* with 2 species each. Based on IUCN criteria and DENR records, a total of 10 species were threatened while only 8 were least concern and the rest were not evaluated. Among those threatened plants, *Cycas riuminiana* was the most notable due to its endemism in MANP. The slash-and-burn farming was one of the several threats witnessed in the mountain. Thus, this checklist is vital as it provides a scientific information on MANP's plant diversity and distribution which is a useful starting point for further ecological and bio-prospective research in the area.

KEY WORDS

Biodiversity; Conservation; endemic; Protected area; Threatened plants.

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INTRODUCTION

Mt. Arayat National Park (MANP) is identified as one of the several areas in the Philippines as a center of biodiversity by the National Biodiversity Strategy and Action Plan (NBSAP) (DENR-UNEP, 1997). This mountain is an isolated and dormant stratovolcano located in the northeastern portion of the province of Pampanga, which covers an aggregate area of 3,715.28 hectares and with the highest

elevation of about 1,030 meters (Dagamac et al., 2014). It lies between 15°12'00"N latitude and 120°43'59"E longitude. When the National Parks Act (Act No. 3195) was enacted in 1932, MANP became one of the oldest national parks and protected areas in the Philippines by the virtue of Proclamation 203 on September 16, 1933 (DENR-PENRO., 2015).

The topography of MANP is rolling to moderately steep in the lower elevations and generally

steep and rugged in the upper portions. A circular volcanic crater of about 1,200 meters in diameter covers the western part, and a portion of the northern rim has collapsed due to soil erosion (Dagamac et al., 2014). The mountain consists of three peaks; the North peak ($15^{\circ}12'00''\text{N}$ - $120^{\circ}44'00''\text{E}$) is where the main summit occurs with its highest elevation of about 1,030 meters via Barangay Ayala, Magalang route, while the South Peak ($15^{\circ}17'35''\text{N}$ - $120^{\circ}76'42''\text{E}$) is about 984 meters via Barangay San Juan Banyo, Arayat route and the Pinnacle Peak ($15^{\circ}10'60''\text{N}$ - $120^{\circ}43'59''\text{E}$) is about 786 meters, situated between the North and the South peaks. The soils of the park originated from residual soils of basalt, sandstone, volcanic tuff and limestone (Bau & Knittel, 1993). The area has an annual temperature range of 2231°C with an annual rainfall range of 284–1,844 mm. Moreover, the MANP is characterized by a moist tropical climate with a period of high precipitation from May to October and six months of relatively dry period from November to April (Dagamac et al., 2012).

The richness and the various native plants in MANP have been used as sources of building materials, food, ornamentals, and medicine. The present forest types of MANP are characterized by secondary deciduous type of forest, with species of *Musa* L., *Ficus* L., and various dipterocarps representing the predominant trees present (Dagamac et al., 2012).

In the Philippines, assessment of plant diversity of different protected areas has already been started in response to the effort of National Integrated Protected Areas System (NIPAS) established in 1992 to sustain biodiversity (La Viña et al., 2010). To cite a few, the works of Replan & Malaki (2007), Amoroso et al., (2009), Villegas & Pollisco (2008), Buot Jr., (2010), Amoroso et al., (2011), Malabrigo Jr., (2013), and Lagbas et al., (2017) have so far published floristic works but no such work was carried out for MANP.

The values of different aspects of this park is now highly realized since the DENR has placed MANP under a Protected Area Suitability Assessment (PASA) to elevate the status of the mountain into a protected landscape (DENR, 2018). Furthermore, the elevation of the area into a protected landscape would be ideal in addressing the need to protect the national park in line with the current situation of human activities in MANP. Once classified as a pro-

tected landscape, this will be designated under the new Republic Act No. 11038 or the Expanded National Integrated Protected Areas System (ENIPAS) Act of 2018. The ENIPAS provides a congruent interaction of man and land while providing opportunities for public enjoyment through recreation and tourism within the normal lifestyle and economic activity of the area (DENR, 2018). To intensify management program on utilization and conservation of plant diversity in MANP, a checklist of biological diversity is very essential. This will give a baseline information on which action plan can be made. Hence, this study aims to provide a preliminary checklist of vascular plants including their conservation status of each plant of MANP, Pampanga, Philippines.

MATERIAL AND METHODS

A research ethics was observed by presenting a letter of request and research proposal to the regional office of the DENR at San Fernando City, Pampanga, Philippines to grant a gratuitous permit. A prior informed consent from the leader of the community who lives in the area was also obtained. Trained Forest Guides were provided for assistance by the Provincial Environment and Natural Resources Officer (PENRO) of Pampanga. Since the nature of the research is participatory, the forest guides were compensated and involved during the entire duration of field work.

Several field visits have been made in the North Peak and South Peak during wet season, September 2016, and dry season, April 2017. According to Rathcke & Lacey (2003), there are correlations between seasonal changes in the physical environment and the simultaneous germination of many species within plant communities. Since the Pinnacle Peak trails are quite dangerous due to its ridgeline, only the North and South Peaks were allowed to be surveyed.

The plant specimens were collected and assessed at the various collecting sites (Fig. 1). Each specimen included information recorded on herbarium collection labels, such as local names, habitat, altitudes, coordinates, etc. Representative specimens collected were pressed, poisoned and mounted as herbarium vouchers using the wet method. Herbarium specimens were labeled and kept at the University of Santo Tomas Herbarium

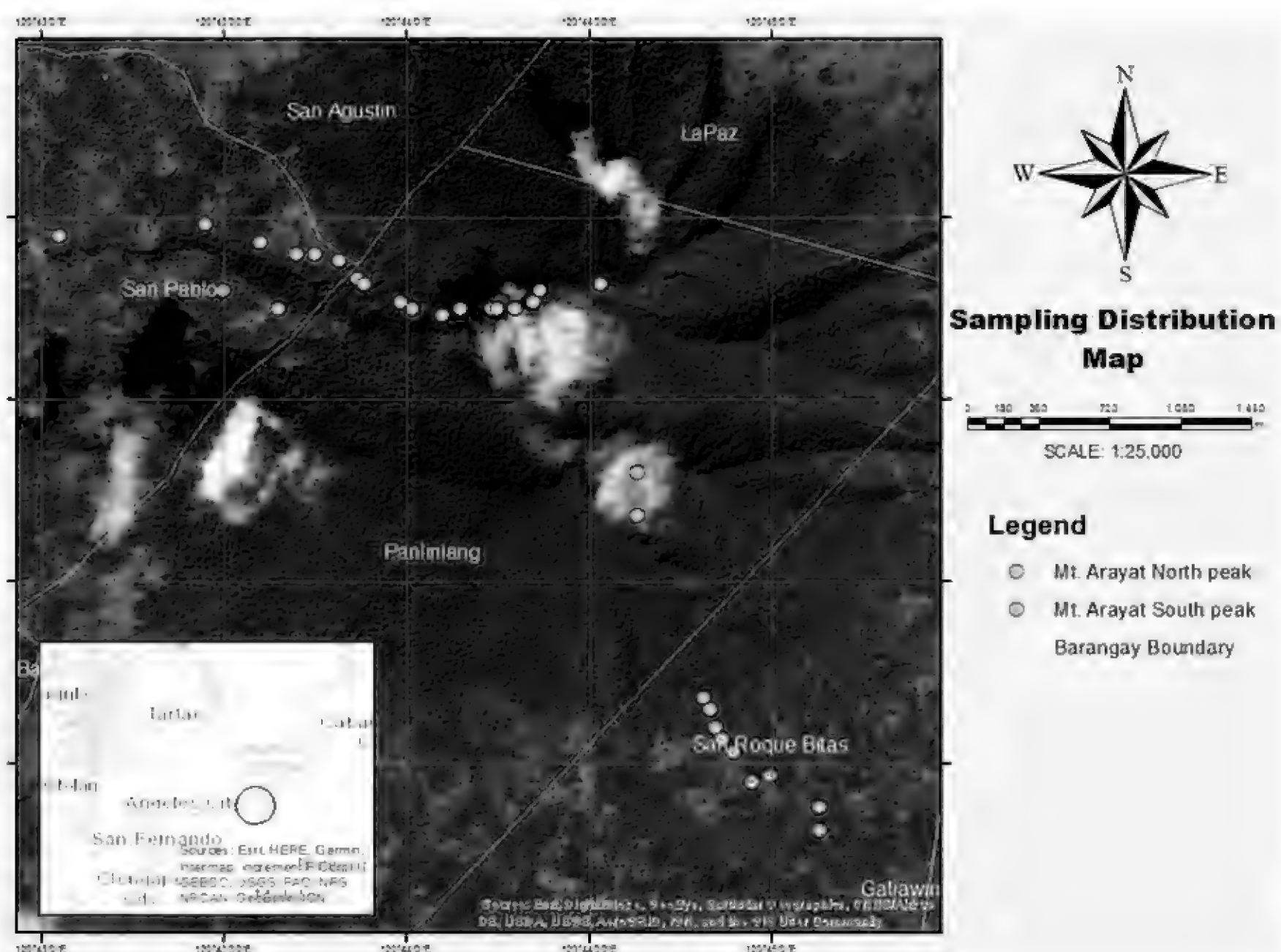


Figure 1. Map of the study sites in MANP. Surveyed areas are marked blue for North peak and green for South peak.

(USTH). All field data gathered were documented in the field notebook and photographs of the different morphological features were used as aid in the succeeding process of identification.

Identification of the collected specimens was conducted at USTH using various literature sources by de Padua & Bunyaphatsōn (1999), Madulid (2001), van Valkenburg & Bunyaphatsara (2002), Keller (2004), Rummel (2005), and Pancho & Gruezo (2006), and some open access websites such as Pelser et al., 2018: Co's Digital Flora of the Philippines (www.philippineplants.org), or type specimens from JSTOR (<https://plants.jstor.org/>) and the Global Biodiversity Information Facility, GBIF (<http://www.gbif.org/>).

To validate the scientific names, The Plant List, 2010 (<http://www.theplantlist.org/>) and Tropicos, 2018 (<http://tropicos.org/>) were accessed, While the authentication of unfamiliar plant taxon was identified by the curator at USTH.

To determine the status for each species, whether Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Other Threatened (OT) and Least Concern (LC), the International Union of Conservation of Nature (IUCN) Red List of Threatened Species and the Department of Environment and Natural Resources (DENR) - Administrative Order No. (DAO) 2017-01 aided in categorizing each species. IUCN and Co's Digital Flora (Pelser et al.) of the Philippines were used to identify endemic plants.

RESULTS AND DISCUSSION

Based on this study, a preliminary list of vascular plant diversity of the MANP was made that includes 98 species under 92 genera and 43 families (Table 1). Of 98 species recorded here, herbs are represented by 16, shrubs by 29, trees by 48, vines

by 1, and epiphytes by 4 species (Table 2). This represents 0.98% of 9,995 species of vascular plants in the Philippines (Pelser et al., 2018). The most dominant family in the park was Leguminosae (10) followed by Euphorbiaceae and Moraceae (7) and Lamiceae (5) (Fig. 2). According to Mancera et al. (2013), the dominance of a plant family is not just affected by the distribution agents in the environment. They suggest distribution patterns of other species, which affect, in turn, the conditions of physical surroundings, like the mimosoid stamens and fruits of the Leguminosae family which allow maximum pollination and dispersion (Carlquist 1974; Gillespie et al., 2011). The legume fruits in particular serve as food to a variety of reptiles and mammals in the forest and hence make them efficient seed dispersers.

In the genus, the most represented was *Ficus* with 3 species, followed by *Artocarpus* J.R. Forster et G. Forster, *Litsea* Lam. and *Macaranga* Thouars with 2 species each. Out of the total 98 species found in the mountain, IUCN Red List and DENR recorded only fifteen (15) and six (6) plant species respectively (Table 3). The IUCN Red List (2018) included one (1) EN, six (6) VU, and eight (8) LC while DENR (2017) identified five (5) VU and one (1) OT plant species which make 0.81% of 984 threatened vascular plants in the Philippines (Co's Digital Flora of the Philippines: Pelser et al., 2018). The OT species refers to a category that is not Critically Endangered, Endangered nor Vulnerable, but is under threat to move to the Vulnerable (DENR-DAO, 2017), while the remaining 84 plant species were marked NE. Both IUCN Red list and DENR categorized *Reutealis trisperma* and *Pterocarpus indicus* as VU species. On the other hand, *Macaranga grandifolia*, *Swietenia macrophylla*, *Artocarpus blancoi*, and *Ficus ulmifolia* were reported by IUCN Red List as VU species but not on the list of DENR. Moreover, *Cycas riuminiana*, *Diospyros pyrrhocarpa*, *Angiopteris palmiformis*, and *Alpinia elegans* are marked as EN, LC, and NE respectively in IUCN Red List. In contrast to DENR, *Cycas riuminiana*, *Diospyros pyrrhocarpa*, and *Alpinia elegans* were assessed as VU while *Angiopteris palmiformis* was labelled as OT. As observed in this study, IUCN and DENR have different categories for a specific species and this is due to their differences in scope or level of assessment (Villanueva & Buot, 2015). Hence, only

15 of the total 98 plant species were on the records based on the indicators formulated by the IUCN and DENR.

Despite being a protected area, most of the park's large area have long been disturbed and utilized. Based on the records of DENR-PENRO (2015), 738 (20%) hectares are covered with secondary growth forest, 928 (25%) hectares are plantation, 1,557.47 (42%) hectares are grassland with patches of reforestation area while the remaining thirteen 13% hectares are covered with intensive land use of crop production like vegetables and agroforestry species by upland farmers.

In this study, a total of 13 (0.30%) out of 4,359 endemic plants in the Philippines were identified based on IUCN (2018) and Co's Digital Flora of the Philippines (Pelser et al., 2018) data. Some of the threatened species which were restricted in the country were *Alpinia elegans*, *Artocarpus blancoi*, and *Ficus ulmifolia*, while *Cycas riuminiana* and *Macaranga grandifolia* were endemic in Luzon. According to Haq et al. (2010), endemic and rare taxa of an area are the most vulnerable because of restricted geographic ranges and specific habitats. Further, other endemic but not threatened species were *Croton batangasensis*, *Lepidopetalum perrottetii*, *Litsea urdanetensis*, *Medinilla multiflora*, and *Micromelum compressum*, while *Claoxylon albicans*, *Pandanus exaltatus* and *Phyllanthus megalanthus* were all endemic in the island of Luzon.

Among these endemic plants, *Cycas riuminiana* is a notable species that was categorized by IUCN Red list as EN and DENR as VU. This species is found in separate localities in lowland mountain forests of Pampanga, Bataan and Batangas in Luzon Island (Madulid & Agoo, 2009). The largest subpopulation is found in MANP, with smaller subpopulations in the other known localities. Based on DNA analysis, there is no significant genetic diversity among the individuals in the provinces of Pampanga, Bataan, and Batangas, thus suggesting that despite the geographical separation, these individuals belong to only one subpopulation. The estimated population is between 1,000 and 1,500 mature individuals (Agoo et al., 2010). Though MANP is a protected area, this endemic plant is highly threatened. According to Agoo et al. (2010), most of the mature plants of *Cycas riuminiana* have been removed in MANP due to the development of an exclusive residential resort area. A telecommu-

Family	Species	Voucher	Habit	Status	Endemicity
Amaranthaceae					
	<i>Achyranthes aspera</i> L.	USTH-014587	H	NE	N
	<i>Alternanthera brasiliana</i> (L.) Kuntze	USTH-014590	H	NE	N
	<i>Cyathula prostrata</i> (L.) Blume	USTH-014672	H	NE	N
	<i>Deeringia polysperma</i> (Roxb.) Moq	USTH-014614	S	NE	N
Anacardiaceae					
	<i>Semecarpus cuneiformis</i> Blanco	USTH-014615	T	NE	N
Annonaceae					
	<i>Anaxagorea luzonensis</i> A. Gray	USTH-014597	S	NE	N
Apocynaceae					
	<i>Alstonia scholaris</i> (L.) R. Br.	USTH-014626	T	LC	N
	<i>Parameria laevigata</i> (Juss.) Moldenke	USTH-014582	S	NE	N
	<i>Wrightia pubescens</i> R.Br.	USTH-014625	T	NE	N
Araceae					
	<i>Alocasia macrorrhizos</i> (L.) G. Don.	USTH-014630	H	NE	N
	<i>Arisaema polyphyllum</i> (Blanco) Merr.	USTH-014618	H	NE	N
	<i>Epipremnum pinnatum</i> (L.) Engl.	USTH-014664	E	NE	N
	<i>Pothos cylindricus</i> C. Presl	USTH-014629	H	NE	N
Araliaceae					
	<i>Schefflera odorata</i> (Blanco) Merr. & Rolfe	USTH-014688	S	NE	N
Asteraceae					
	<i>Chromolaena odorata</i> (L.) R.M.King & H. Rob	USTH-014661	S	NE	N
	<i>Cosmos sulphureus</i> Cav	USTH-014686	H	NE	N
	<i>Mikania cordata</i> (Burm.f.) B.L. Rob.	USTH-014606	H	NE	N
	<i>Pseudelephantopus spicatus</i> (B.Juss. ex Aubl.) Rohr ex C.F.Baker	USTH-014687	H	NE	N
Burseraceae					
	<i>Canarium hirsutum</i> Willd.	USTH-014639	T	NE	N
	<i>Garuga floribunda</i> Deene.	USTH-014586	T	NE	N
Celastraceae					
	<i>Euonymus cochinchinensis</i> Pierre	USTH-014583	T	LC	N
Chloranthaceae					
	<i>Sarcandra glabra</i> (Thunb.) Nakai	USTH-014650	S	NE	N
Combretaceae					
	<i>Combretum punctatum</i> Blume.	USTH-014570	T	NE	N
Commelinaceae					
	<i>Polia secundiflora</i> (Blume) Bakh.f.	USTH-014621	H	NE	N
Cornaceae					
	<i>Alangium chinense</i> (Lour.) Harms	USTH-014652	T	NE	N
Cycadaceae					
	<i>Cycas ruminiana</i> Regel	USTH-014658	T	EN/*VUL	E
Cyperaceae					
	<i>Scleria terrestris</i> (L.) Fasset	USTH-014572	H	LC	N
Dioscoreaceae					
	<i>Tacca palmata</i> Blume	USTH-014631	H	NE	N
Ebenaceae					
	<i>Diospyros pyrrhocarpa</i> Miq.	USTH-014581	T	LC/*VUL	N
Euphorbiaceae					
	<i>Claoxylon albicans</i> (Blanco) Merr.	USTH-014613	T	NE	E
	<i>Croton batangasensis</i> Croizat	USTH-014569	T	NE	E
	<i>Reutealis trisperma</i> (Blanco) Airy Shaw	USTH-014635	T	V/*V	N
	<i>Macaranga grandifolia</i> (Blanco.) Merr.	USTH-014603	T	V	E
	<i>Macaranga tanarius</i> (L.) Müll.Arg.	USTH-014685	T	NE	N
	<i>Manihot esculenta</i> Crantz	USTH-014666	S	NE	N
	<i>Melanolepis multiglandulosa</i> (Reinw. ex Blume) Reichb. & Zoll.	USTH-014678	T	NE	N

Table 1/1. List of vascular plants identified in MANP. Plant families are alphabetically arranged, followed by species for each family, vouchers, habit (T = tree, S = shrub, H = herb, V = vine, E = epiphyte), proposed conservation status based on IUCN Red List of Threatened Species or *DENR Administrative Order 2017-11 (NE = Not Evaluated, DD = Data Deficient, LC = Least Concern, OT = Other Threatened, VU = Vulnerable, EN = Endangered, CR = Critically Endangered), and endemicity based on IUCN and Co's Digital Flora (E = Philippine endemic, N = non-endemic). All collections done by MDL Suba.

Family	Species	Voucher	Habit	Status	Endemicity
Lamiaceae					
	<i>Callicarpa canidans</i> (Burm.f.) Hochr.	USTH-014584	S	NE	N
	<i>Gmelina arborea</i> Roxb.	USTH-014660	T	NE	N
	<i>Hyptis suaveolens</i> (L.) Poit.	USTH-014673	S	NE	N
	<i>Premna odorata</i> Blanco	USTH-014697	T	NE	N
	<i>Tectona grandis</i> L.f.	USTH-014691	T	NE	N
Lauraceae					
	<i>Litsea urdanetensis</i> Elmer (unresolved)	USTH-014592	T	NE	E
	<i>Litsea glutinosa</i> (Lour.) C.B. Rob.	USTH-014568	T	NE	N
Leguminosae					
	<i>Albizia lebbek</i> (L.) Benth.	USTH-014689	T	NE	N
	<i>Bauhinia integrifolia</i> Roxb.	USTH-014574	S	NE	N
	<i>Caesalpinia pulcherrima</i> (L.) Sw.	USTH-014567	S	NE	N
	<i>Gliricidia sepium</i> (Jacq.) Kunth ex. Steud.	USTH-014662	S	NE	N
	<i>Mimosa diplotricha</i> Sauvalle	USTH-014588	S	NE	N
	<i>Parkia timoriana</i> (DC.) Merr.	USTH-014623	T	NE	N
	<i>Pongamia pinnata</i> (L.) Pierre	USTH-014653	T	LC	N
	<i>Pterocarpus indicus</i> Willd.	USTH-014696	T	V/*V	N
	<i>Tamarindus indica</i> L.	USTH-014698	T	LC	N
Lythraceae					
	<i>Lagerstroemia speciosa</i> (L.) Pers.	USTH-014576	T	NE	N
Malvaceae					
	<i>Heritiera sylvatica</i> S. Vidal	USTH-014627	S	NE	N
	<i>Kleinhovia hospita</i> L.	USTH-014589	T	NE	N
	<i>Sida acuta</i> Burm. f.	USTH-014672	S	NE	N
	<i>Triumfetta rhomboidea</i> Jacq.	USTH-014693	S	NE	N
Marattiaceae					
	<i>Angiopteris palmiformis</i> (Cav.) C. Chr.	USTH-014611	T	NE/*OT	N
Melastomataceae					
	<i>Melastoma malabathricum</i> L.	USTH-014609	S	NE	N
	<i>Memecylon lanceolatum</i> Blanco	USTH-014654	T	NE	N
	<i>Medinilla multiflora</i> Merr.	USTH-014610	S	NE	E
Meliaceae					
	<i>Sandoricum koetjape</i> (Burm.f.) Merr.	USTH-014622	T	LC	N
	<i>Swietenia macrophylla</i> King	USTH-014667	T	V	N
Moraceae					
	<i>Artocarpus blancoi</i> (Elmer) Merr.	USTH-014634	T	V	E
	<i>Artocarpus heterophyllus</i> Lam.	USTH-014673	T	NE	N
	<i>Broussonetia luzonica</i> (Blanco) Bureau	USTH-014674	T	NE	N
	<i>Ficus nota</i> (Blanco.) Merr.	USTH-014671	T	NE	N
	<i>Ficus ulnifolia</i> Lam.	USTH-014636	T	V	E
	<i>Ficus septica</i> Burm.f.	USTH-014692	T	NE	N
	<i>Streblus asper</i> Lour.	USTH-014680	T	NE	N
Pandanaceae					
	<i>Pandanus exaltatus</i> Blanco	USTH-014607	T	NE	E
Passifloraceae					
	<i>Passiflora foetida</i> L.	USTH-014695	V	NE	N
Phyllanthaceae					
	<i>Antidesma humius</i> (L.) Spreng	USTH-014669	T	NE	N
	<i>Breynia cernua</i> (Poir.) Müll. Arg.	USTH-014566	S	NE	N
	<i>Bridelia insulana</i> Hance	USTH-014573	T	NE	N
	<i>Phyllanthus megalanthus</i> C.B. Rob.	USTH-014617	S	NE	E
Poaceae					
	<i>Paspalum conjugatum</i> P.J. Bergius	USTH-014602	H	LC	N
	<i>Schizostachyum diffusum</i> (Blanco) Merr.	USTH-014651	S	NE	N
Polypodiaceae					
	<i>Microsorium longissimum</i> (J.Sm.) Fee	USTH-014628	E	NE	N
	<i>Microsorium membranifolium</i> (R.Br.) Ching	USTH-014640	E	NE	N
Primulaceae					
	<i>Ardisia pyramidalis</i> Roth.	USTH-014605	S	NE	N

Table 1/2. List of vascular plants identified in MANP. Plant families are alphabetically arranged, followed by species for each family, vouchers, habit (T = tree, S = shrub, H = herb, V = vine, E = epiphyte), proposed conservation status based on IUCN Red List of Threatened Species or *DENR Administrative Order 2017-11 (NE = Not Evaluated, DD = Data Deficient, LC = Least Concern, OT = Other Threatened, VU = Vulnerable, EN = Endangered, CR = Critically Endangered), and endemicity based on IUCN and Co's Digital Flora (E = Philippine endemic, N = non-endemic). All collections done by MDL Suba.

Family	Species	Voucher	Habit	Status	Endemicity
	<i>Maesa indica</i> (Roxb.) A. DC.	USTH-014608	S	NE	N
Proteaceae					
	<i>Helicia robusta</i> (Roxb.) R.Br. ex. Wall	USTH-014601	T	NE	N
Pteridaceae					
	<i>Pteris tripartita</i> Sw.	USTH-014594	E	NE	N
Rubiaceae					
	<i>Tarrenoidea wallichii</i> (Hook.f.) Tirveng & Sastre	USTH-014598	T	NE	N
Rutaceae					
	<i>Lunasia amara</i> Blanco	USTH-014668	T	NE	N
	<i>Micromelum compressum</i> (Blanco) Merr.	USTH-014599	T	NE	E
	<i>Severinia disticha</i> (Blanco) Swingle (unresolved)	USTH-014656	S	NE	N
Sapindaceae					
	<i>Allophylus cobbe</i> (L.) Racusch.	USTH-014602	S	NE	N
	<i>Lepidopetalum perrottetii</i> Blume	USTH-014585	T	NE	E
	<i>Sapindus saponaria</i> L.	USTH-014694	T	NE	N
Selaginellaceae					
	<i>Selaginella engleri</i> Hieron	USTH-014683	H	NE	N
Thymelaeaceae					
	<i>Wikstroemia lanceolata</i> Merr.	USTH-014619	S	NE	N
Verbenaceae					
	<i>Lantana camara</i> L.	USTH-014665	S	NE	N
	<i>Stachytarpheta cayennensis</i> (Rich.) Vahl	USTH-014637	S	NE	N
Vitaceae					
	<i>Leea guineensis</i> G. Don	USTH-014604	S	NE	N
Zingiberaceae					
	<i>Alpinia elegans</i> (C.Presl) K.Schum.	USTH-014620	H	NE/*V	E

Table 1/3. List of vascular plants identified in MANP. Plant families are alphabetically arranged, followed by species for each family, vouchers, habit (T = tree, S = shrub, H = herb, V = vine, E = epiphyte), proposed conservation status based on IUCN Red List of Threatened Species or *DENR Administrative Order 2017-11 (NE = Not Evaluated, DD = Data Deficient, LC = Least Concern, OT= Other Threatened, VU = Vulnerable, EN = Endangered, CR = Critically Endangered), and endemicity based on IUCN and Co's Digital Flora (E = Philippine endemic, N = non-endemic). All collections done by MDL Suba.

nications tower was also built at the peak of the mountain. During the course of field work of this study, other several threats were also observed such as expansion of agricultural lands, which was mostly seen in the South peak, caused by deforestation through slash-and-burn farming. Those trees that burned were used for charcoal making. Other human activities such as irresponsible camping practices of visitors and limited manpower were also noticed.

At present, several projects have been launched to rehabilitate and conserve resources of MANP. The Community Based Program (CBP) is DENR Administrative Order No. 2004-32 which gives opportunities to organize tenured migrant communities and indigenous people to manage, develop, utilize, conserve and protect the resources within the zones of the protected area and consistent buffer zones with the Protected Area Management Plan (PAMP). The Treepreneur Project of Society for the conservation of Philippine wetlands brought in participation of women and children in tree planting

activities and maintenance of the assigned plantation areas at MANP were made (SCPW, 2012). Lastly, a new eco-tourist destination will soon rise in Central Luzon. The 10-hectare San Juan Baño recreational facility at the foot of the fabled MANP will undergo major renovation and rehabilitation under a public-private sector partnership scheme proposed by the local government of Arayat (DENR, 2018).

CONCLUSIONS

The present study provided a preliminary checklist with emphasis on conservation status of vascular plants in MANP, Pampanga, Philippines. The following conclusions are: 98 plant species from 43 families were documented, there is 1 Endangered, 8 Vulnerable and 1 other Threatened plant species; 13 plant species were found endemic, with *Cycas ruminiana* being the most notable; and (3) different threats to biodiversity in MANP were also observed

Plant Groups	Total Number of		
	Families	Genera	Species
Trees	24	43	48
Shrubs	19	29	29
Herbs	9	16	16
Vines	1	1	1
Epiphytes	3	3	4
		Total	98

Table 2. Taxonomic inventory of vascular plants in MANP.

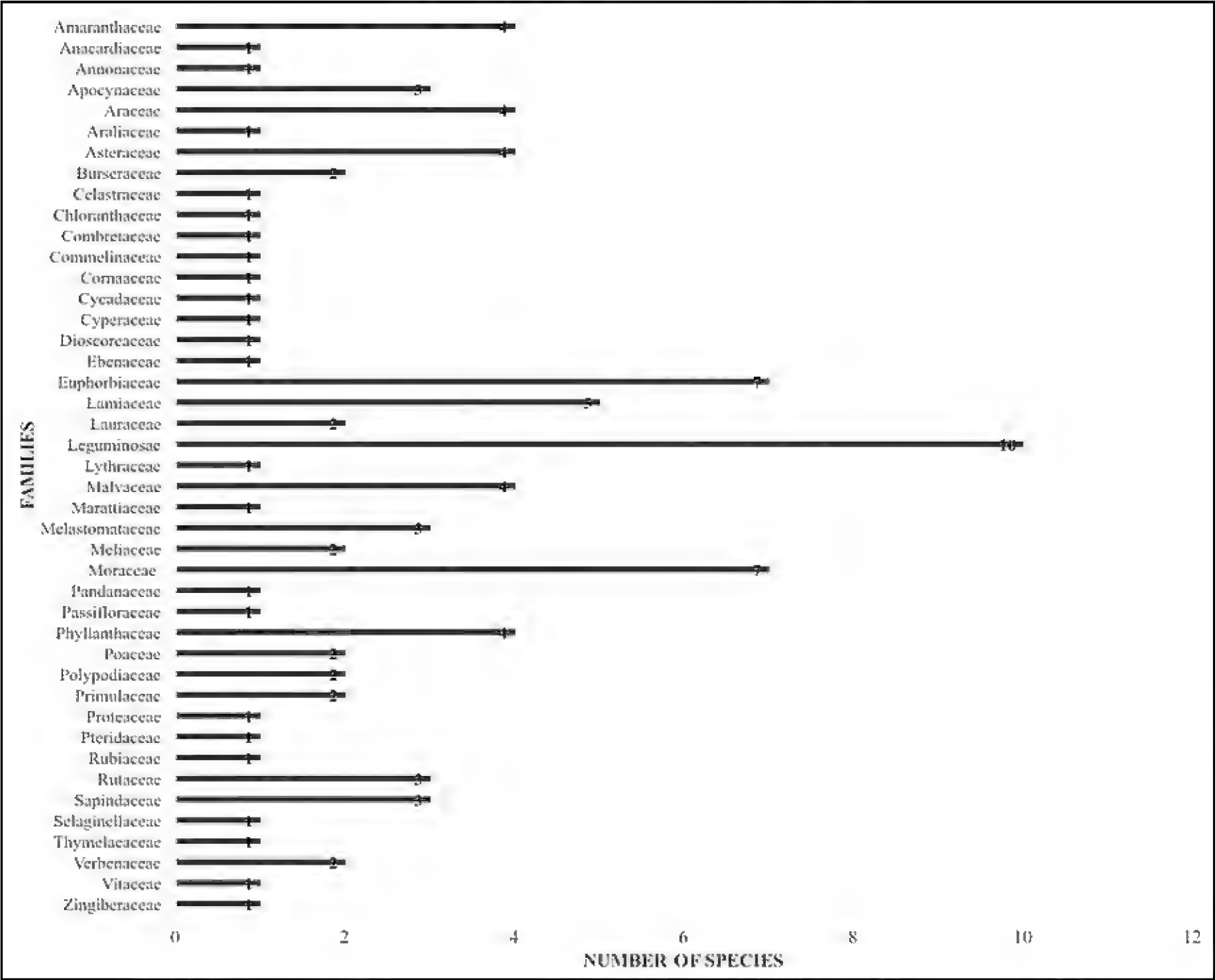


Figure 2. The most common families of vascular plant species recorded in MANP.

during field works. Noteworthy threats are charcoal making at the slopes of the mountain, specifically in South Peak. Charcoal making utilizes slash-and-burn techniques that reduce plant cover. The lack of discipline and irresponsible camping practices of visitors, and limited manpower were also observed.

Though there were only few documented plant species under threat, it cannot be denied that biological diversity is rapidly fading in forest, upland, and even in coastal environments in the Philippines and throughout the world. Several management options can be done such as distribution map of threat-

Categories	IUCN	DENR	Total
Critically Endangered (CR)	0	0	0
Endangered (EN)	1	0	1
Vulnerable (VU)	6	5	*8
Other Threatened (OT)	0	1	1
Least Concern (LC)	8	0	
Data deficient (DD)	0	0	
Not evaluated (NE)	83	92	
Total (CR, EN, VU, OT)			10

Table 3. Summary of Threatened and Least Concern vascular plant species found in MANP. *If IUCN or DENR listed same plant species, the plant species is counted as one.

ened plant species. Such map will facilitate accurate location and home range of threatened species in the MANP so that monitoring activities can be carried out easily. In severe cases, ex situ conservation for particular species may be followed to improve their population number. This is a preliminary checklist of vascular plants; the plant diversity is likely to be higher. The inventory of other plants such as bryophytes is also recommended for future studies. Nevertheless, this study has significantly increased the biodiversity knowledge of the park by gaining more detailed insight in the composition of the various vegetation types that can be used to intensify management program on utilization and conservation of MANP.

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REFERENCES

Agoo E.M.G., Madulid D.A., Linis V.C. & Sambale E., 2010. *Cycas riuminiana*. The International Union for Conservation of Nature’s Red List of Threatened Species. <http://www.iucnredlist.org>.
Amoroso V.B., Laraga S.H. & Calzada B.V., 2011. Diversity and assessments of plants in Mt. Kitanglad

Range Natural Park, Bukidnon, Southern Philippines. Gard Bull Singapore, 63: 219–236.
Amoroso V.B., Obsioma L.D., Arlalejo J.B., Aspiras R.A., Capili D.P., Polizon J.J.A. & Sumile E.B., 2009. Inventory and conservation of endangered, endemic and economically important flora of Hamiguitan Range, Southern Philippines. *Blumea*, 54: 71–76. <https://doi.org/10.3767/000651909X474113>
Bau M. & Knittel U., 1993. Significance of slab-derived partial melts and aqueous fluids for the genesis of tholeiitic and talc-alkaline island-arc basalts: evidence from Mt. Arayat, Philippines. *Chemical Geology*, 105: 233–251.
Buot I.E. & Jr., 2010. Conservation status of the commonly collected plant species in selected Philippine mountain ecosystems. *The Journal of Tropical Biology*, 8: 3–13. <https://doi.org/10.1127/0029-5035/2013/0142>
Dagamac N.H., Stephenson S. & Dela Cruz T.E., 2014. The occurrence of litter Myxomycetes at different elevations in Mt. Arayat National Park, Pampanga, Philippines. *Nova Hedwigia*, 98: 187–196.
Dagamac N.H., Stephenson S. & dela Cruz T.E., 2012. Occurrence, distribution, and diversity of myxomycetes (plasmodial slime molds) along two transects in Mt. Arayat, National Park, Pampanga, Philippines. *Mycology*, 3: 119–126.
De Padua L.S. & Bunyaphrathatsō N., 1999. Medicinal and poisonous plants. Backhuys Publishers.
DENR Administrative Order, 2017. Updated national list of threatened Philippine plants and their categories. DAO2017-11 <https://server2.denr.gov.ph/uploads/rmdd/dao-2017-11.pdf>.
DENR-PAWB, 2009. Assessing progress towards the 2010 biodiversity target. The 4th National Report to the Convention on Biological Diversity Republic of the Philippines. www.cbd.int/doc/world/ph/ph-nr-04-en.pdf.
DENR-PENRO, 2015. Mt. Arayat National Park-Protected Area Management Plan. Department of Environment and Natural Resources Provincial - Environment and Natural Resources Officer. Region III, Pampanga, 1 pp.
DENR-Region III, Central Luzon. 2018. World-class tourist destination to rise in Mt. Arayat National Park. Accessed at: <http://r3.denr.gov.ph/>.
DENR/UNEP (Department of Environment and Natural Resources/United Nations Environment Program), 1997. Philippine Biodiversity: An assessment and action plan. Bookmark Inc., Makati City, Philippines. 298 pp.
GBIF.org, 2018. Global Biodiversity Information Facility. <https://www.gbif.org>.
Gillespie T.W., Keppel G., Pau S., Price J.P., Jaffre T., Meyer J. & O’Neill K., 2011. Floristic composition and natural history characteristics of dry forests in the

- Pacific. *Pacific Science*, 65: 127–141. <https://doi.org/10.2984/65.2.127>
- Haq F.H., Alam M. & Phil M., 2010. Thesis, on Species Diversity of Vascular Plants of Nandiar Khuwar Battagram, 110 pp.
- IUCN, 2018. The International Union for Conservation of Nature Red List of Threatened Species. Version 2018-1. <http://www.iucnredlist.org>.
- JSTOR, 2018. JournalStorage, Accessed <https://plants.jstor.org/>.
- Keller R., 2004. Identification of tropical woody plants in the absence of flowers: A field guide. Birkhäuser, Basel, Switzerland.
- La Viña A.G.M., Kho J.L. & Caleda M.J., 2010. Legal Framework for Protected Areas: Philippines. Gland, Switzerland: IUCN. <http://cmsdata.iucn.org/downloads/philippines.pdf>
- Lagbas A., Buot I.E. Jr. & Mendoza L., 2017. Conservation status of the plant species in selected areas with frequent human activities in Roosevelt Protected Landscape, Bataan, Luzon Island, Philippines. *The Thailand Natural History Museum Journal*, 10: 79–115.
- Madulid D.A. & Agoo E.M.G., 2009. Taxonomy and conservation of Philippine cycads. *Blumea*, 54: 99–102. <https://doi.org/10.3767/000651909X474140>
- Madulid D.A., 2001. A dictionary of Philippine plant names. 2 volumes. Makati City, Inc., Makati, Philippines.
- Malabrigo P.L. Jr., 2013. Vascular flora of the tropical montane forests in Balbalasang-Balbalan National Park, Kalinga province, Northern Luzon, Philippines. *Asian Journal of Biodiversity*, 4: 1–22. <https://doi.org/10.7828/ajob.v4i1.294>
- Mancera J.P., Ragragio E.M., Sia Su G.L. & Rubite R.R., 2013. Plant community structure of a secondary forest at Barangay Camias, Porac, Pampanga, The Philippines. *Philippine Journal of Science*, 142: 135–143.
- Pancho J.V. & Gruezo W.S., 2006. Vascular flora of Mount Makiling and vicinity (Luzon, Philippines), Part 2. National Academy of Science and Technology (NAST) Philippines, Department of Science and Technology, Bicutan, Taguig City and Institute of Biological Sciences, University of the Philippines Los Baños, College, Laguna, Philippines (Publishers).
- Pelser P.B., Barcelona J.F. & Nickrent D.L. (Eds.), 2018. Co's Digital Flora of the Philippines. <http://www.philippineplants.org>.
- Rathcke B.J. & Lacey E., 2003. Phenological patterns of terrestrial plants. *The Annual Review of Ecology, Evolution and Systematics*, 16: 179–214. <https://doi.org/10.1146/annurev.es.16.110185.001143>
- Replan E.L. & Malaki A.B., 2017. Floral diversity and habitat assessment of Canbantug forest, Argao, Central Visayas, Cebu, Philippines. *International Journal of Scientific & Engineering Research*, 8: 775–780.
- Rummel D.J., 2005. Useful plants of the Philippines. Quezon City, Philippines: Published and distributed by C&E Pub.
- Society for the conservation of Philippine wetlands (SCPW), 2012. The Trepreneur Project. <http://www.wetlands.ph/projects/trepreneurship/>.
- The Plant List, 2010. The Plant List: A working list of all plant species. <http://www.theplantlist.org/>.
- Tropicos.org., 2018. Missouri Botanical Garden. <http://www.tropicos.org>.
- Vanvalkenburg J.L. & Bunya P.N., 2002. Plant Resource of south East Asia. Medicinals plant. PROSEA, Foundation, Bogor, Indonesia.
- Villanueva E.L.C. & Buot I.E. Jr., 2015. Threatened plant species of Mindoro, Philippines. *IAMURE. International Journal of Ecology and Conservation*, 14: 168–189. <https://doi.org/10.7718/ijec.v14i1.901>
- Villegas K.L. & Pollisco F.A., 2008. Floral survey of Laiban Sub-Watershed in the Sierra Madre Mountain Range in the Philippines. *Journal of Tropical Biology and Conservation*, 4: 1–14.

Diversity of vertebrate and invertebrate scavenging communities of reptile carcasses in the piedmont of North Carolina, USA

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ABSTRACT

Scavenging of animal carcasses (carrion) is an important ecological process, which occurs when insects and vertebrates either aid in decomposition or removal of carcasses. However, very little is known regarding which species typically scavenge or which forensically important insects colonize recently deceased reptile carrion and in what relative frequencies. To this end, we deployed three reptile carcasses, a box turtle (*Terrapene carolina*), a snapping turtle (*Chelydra serpentina*), and black rat snake (*Pantherophis obsoletus*) near a road and monitored vertebrate and invertebrate scavengers visiting carcasses with non-invasive camera traps and manual collection of insects visiting carcasses during the Spring of 2018 near Wingate, North Carolina, USA. In total, we collected 233 invertebrates present on the carcass by hand net capture representing 14 taxonomic insect groupings and observed 16 vertebrate species (mammals and birds) from 86 observations scavenging on the remains, with white-footed deer mouse (*Peromyscus leucopus*), and Virginia opossum (*Didelphis virginiana*) being the most frequent vertebrate scavengers detected on camera traps. Carcasses were colonized by several insects including the orders Coleoptera from families Silphidae carrion beetles (*Oiceoptoma noveboracense* and *Oiceoptoma inaequale*) and Staphylinidae (*Platydracus* sp.), the order Diptera representing families Piophilidae (*Prochyliza* sp.), Calliphoridae (*Calliphora* sp. and *Luicilla* sp.), Muscidae (*Musca* sp.), and Stratiomyidae (*Hermetia* sp.) and order Hymenoptera family Formicidae (*Prenolepsis* sp.). This report adds to our knowledge on the biodiversity of both invertebrate and vertebrate scavenging guild communities which rely on reptile carrion as an ecological resource in terrestrial semi-forested environments.

KEY WORDS

Carrion ecology; forensic entomology; scavenger diversity; insect community; camera traps.

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INTRODUCTION

The decomposition of vertebrate carcasses (carrion) can generate a great deal of biological activity and have important ecological impacts, with carcass nutrients supporting populations of both microbial, insect, and vertebrates (scavengers) in nature (Van-

Laerhoven & Anderson, 1999; Melis et al., 2004; Carter et al., 2007; Beasley et al., 2012). Moreover, reptiles are often the victims of direct mortality in both urban and semi-rural environments and near protected areas as a result of roads, with common roadkill mortality including snapping turtles, *Chelydra serpentina* (Linnaeus, 1758), box turtles *Ter-*

rapene carolina (Linnaeus, 1758), and *Pantherophis obsoletus* (James, 1823), the black rat snake (Haxton, 2000; Smith & Dodd, 2003; Row et al., 2007; Andrews et al., 2008). The availability of carrion can influence local diversity and food webs of vertebrate scavengers as well as insects in urban ecosystems (Inger et al., 2016; Schwartz et al., 2018). However, very little research has assessed the biodiversity of both carcass insect colonizers and vertebrate scavengers which in the short term may rely on road mortality reptiles as either a nutrient resource or as a location for deposition of eggs by a variety of insects.

There are diverse groups of forensically important, necrophagous insects which colonize carrion (Amendt et al., 2007), including primarily members of the insect orders Diptera and Coleoptera (Benecke, 2001; Kulshreshta & Satpathy, 2001). Camera traps (trail cameras) are useful to non-invasively monitor wildlife populations and scavenging behavior in mammals (Devault et al., 2004; Pomezanski & Bennett, 2018; Schlichting et al., 2019). Presently, there is a dearth of information on either the frequency of reptile carrion scavenged by local wildlife (Antworth et al., 2005; Abernathy et al., 2017) or the extent of insect colonization on reptile carcasses (Watson & Carlton, 2005a, b). Moreover, in addition to mammals, both traditional scavenging and opportunistic species of birds may frequent carcasses (Inger et al., 2016), indicating carrion may help maintain local biodiversity across multiple taxonomic groups. In addition, most studies on forensic entomology rely on using the mammalian porcine model (*Sus scrofa* Linnaeus, 1758) as a carcass, with little knowledge available on other types of vertebrate carcass types which may also be utilized by local organismal communities (Schoenly et al., 2006). The aim of this work is to identify the diversity of scavenging vertebrates and colonizing invertebrates (forensic entomology) of reptile carcasses using both non-invasive camera traps and direct sampling of insects colonizing carcass.

MATERIAL AND METHODS

Field Sampling

During the Spring of 2018, we deployed three

reptile carcasses, one black rat snake (*Pantherophis obsoletus*), and two turtle species, an eastern box turtle (*Terrapene carolina*) and common snapping turtle (*Chelydra serpentina*) on 10.IV.2018, 10.IV.2018 and 27.III.2018, respectively in the central Piedmont area of Wingate, North Carolina, USA. All carcasses were collected recently deceased (under ~12 hours at the same location). Animals were obtained in coordination of North Carolina Wildlife Resources Commission, double-bagged and frozen until deployed. Carcasses were deployed in a wooded area at Wingate University Campus Lake area (latitude 34,988 and longitude 80,429; 170 meters elevation), a mixture of *Quercus* and *Pinus* forest, within 20 meters of roads but in a wooded area to simulate roadkill conditions. Each carcass was separated by a minimal distance of 50 meters to prevent cross contamination by insects following Perez et al. (2016). For each carcass, we deployed a total of three trail cameras positioned at varying angles of carcass to maximize detection of potential scavengers and in close enough proximity to differentiate smaller organisms. A small area of the leaf litter was cleared and carcasses were placed in the center of a trail camera array consisting of three Bushnell trail cameras (model 119637C) positioned facing the carcass area secured to nearby trees. This array allowed multiple angles of trail cameras in case images were blurry for any one trail camera. Cameras were set to record in 24 hr mode, motion capture at medium LED control, 14 M pixel, and 3 images per event. Cameras were deployed until 9.V.2018, to allow documentation of mammalian and bird visitors to carcasses at later decomposition stages (post-decay/dry stage; Kreitlow, 2010) and to detect potentially rare mammalian species (i.e., skunk, etc.), with low probabilities of detection (Shannon et al., 2014). We also recorded daily temperatures using HOBO® temperature data loggers during the experiment.

We visited carcasses daily during the first week of deployment, then periodically (every two days) following the first week for 26 days to collect insects actively scavenging or on the surface, or immediately below ground of each carcass. Insects scavenging carcass were collected using a combination of forceps, a sweep net, and insect aspirator and stored in 95% ethanol until identification. We were careful when collecting insects to never re-

move more than five individuals of any one species per carcass to prevent compromising colonization of carcass by other insects and decomposition rates.

Data Analysis

We identified insects on carcasses to the lowest taxonomic level possible. We calculated the species richness and Shannon Diversity index for insects collected. We reviewed trail camera images to identify the frequency of carcass visitations by mammals and birds. Each of the three trail cameras were viewed by authors and the best image for identification was used to validate species level identification and time of visit to each carcass type. We characterized images (visits by birds or mammals) captured by camera traps as temporally independent (a single observation) if they were separated by a minimum of 30 minutes. However, we have no information if the same individual repeatedly visited a single carcass, and therefore report this information as observations.

RESULTS

In total, we detected 16 mammal species (86 individual observations) visiting our carcasses (Fig. 1), with one, the Virginia opossum, *Didelphis virginiana* (Kerr, 1792), fully removing and consuming our black rat snake carcass on the seventh day, on 16.IV.2018 (Fig. 1). Both turtle carcasses remained present through various decomposition stages. We also observed Raccoon, *Procyon lotor* (Linnaeus, 1758) (Fig. 2), Grey Fox, *Urocyon cinereoargenteus* (Schreber, 1775) (Fig. 3), Turkey Vulture, *Cathartes aura* (Linnaeus, 1758) (Fig. 4), and Striped Skunk, *Mephitis mephitis* (Schreber, 1776), visiting carcasses. Across carcass types, the white-footed deer mouse, *Peromyscus maniculatus* (Wagner, 1845), accounted for the most visits to carcasses, with Virginia opossum, *D. virginiana*, Eastern grey squirrel, *Sciurus carolinensis* Gmelin, 1788, and Northern Cardinal, *Cardinalis cardinalis* (Linnaeus, 1758) among the most frequent mammalian and bird observations on camera traps (Fig. 5). Additional species (Fig. 6) which visited

Carcass Type	Frequency	Order	Family	Taxon
CS, TC,	40	Diptera	Silphidae	<i>Oiceoptoma noveboracense</i> (Forster, 1771)
CS, TC, PO	13			<i>Oiceoptoma inequale</i> (Fabricius, 1781)
PO	1			<i>Thanatophilus lapponicus</i> (Herbst, 1793)
TC	1		Scarabaeidae	<i>Onthophagus</i> sp.
CS, TC	4		Staphylinidae	<i>Platydracus</i> sp.
CS	39		Piophilidae	<i>Prochyliza</i> sp.
PO, CS	8		Calliphoridae	<i>Lucilla sericata</i>
CS	2			<i>Calliphora</i> sp.
CS, TC	17		Muscidea	<i>Musca domestica</i> (Linnaeus, 1758)
CS	7		Stratiomyidae	<i>Hermetia</i> sp.
CS	1		Sarcophagidae	<i>Sarcophaga</i> sp.
CS, TC	41		unknown	instars
PO, TC	21	Hymenoptera	Formicidae	<i>Prenolepsis</i> sp.
CS	2			<i>Formica</i> sp.
CS	1	Blattodea	Blattidea	<i>Parcoblatta</i> sp.
Total	198			
Species richness	14			
Shannon Diversity index	1.797			

Table 1. Insects identified on carcass by type (*Chelydra serpentina* [CS], *Terrapene carolina* [TC], and *Pantherophis obsoletus* [PO]), frequency, and taxonomic designation. Note: unknown Diptera or non-insect arthropods not included in species richness or Shannon Diversity Index calculations.



Figures 1–4. Examples of Trail Camera images showing scavengers, including common opossum on rat snake (Fig. 1), raccoon on snapping turtle (Fig. 2), grey fox on box turtle (Fig. 3), and turkey vulture on snapping turtle (Fig. 4).

the carcasses included the Brown thrasher, *Toxostoma rufum* (Linnaeus, 1758), Eastern cottontail rabbit, *Sylvilagus floridanus* (J.A. Allen, 1890), White-tailed deer, *Odocoileus virginianus* (Zimmermann, 1780), Domestic cat, *Felis catus* (Linnaeus, 1758), Brown-headed cowbird, *Molothrus ater* (Boddaert, 1783), American robin, *Turdus migratorius* Linnaeus, 1766, American crow, *Corvus brachyrhynchos* Brehm, 1822, and Carolina wren, *Thryothorus ludovicianus* (Latham, 1790). In total, camera traps recorded 5,459 images (three camera traps per carcass) with 2,212 images for box turtle carcass, 1,427 images for rat snake carcass, and 1,820 images for the snapping turtle carcass. Many images represented pictures with no bird or mammal individuals present or duplicate images of the same organism visiting carcasses from multiple camera traps. In addition, several images depicted larger fly adults and carrion beetle adults visiting carcasses, but image quality was of low resolution

based on the distance of trail camera to carcass for identification further than Diptera or Coleoptera and are not included in this study. These 86 mammalian and bird observations consisted of 52 observations on the box turtle, 21 observations on the snapping turtle carcass, and only 13 observations on the snake carcass. The majority of camera trap images were recorded each day during 20:00 to 5:00 hours, or nocturnal and crepuscular (Fig. 7). Temperatures during the experiment (insect collection and camera trapping) ranged from average minimal lows of 8.6 °C to average maximum daily temperatures of 22.1 °C.

We identified 17 taxonomic groups of invertebrates (14 insect groupings) associated with our three reptile carcasses, albeit at different frequencies (Table 1). We observed three insect orders across carcasses: Coleoptera, Diptera and Hymenoptera. Insect families present on the snake carcass included Silphidae, Calliphoridae, and

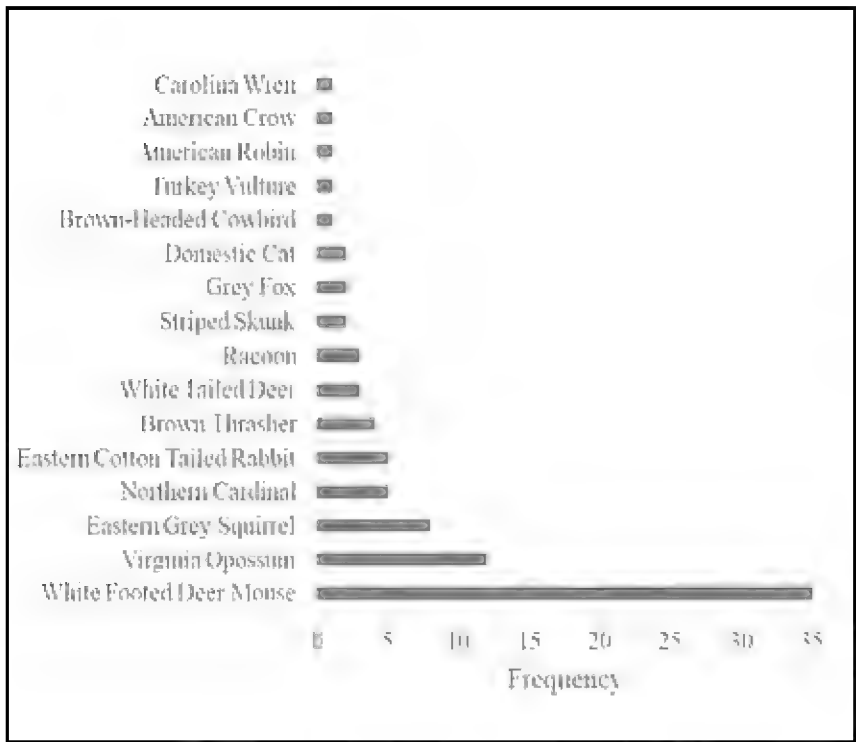


Figure 5. Relative frequency of vertebrate scavengers observed on camera traps.

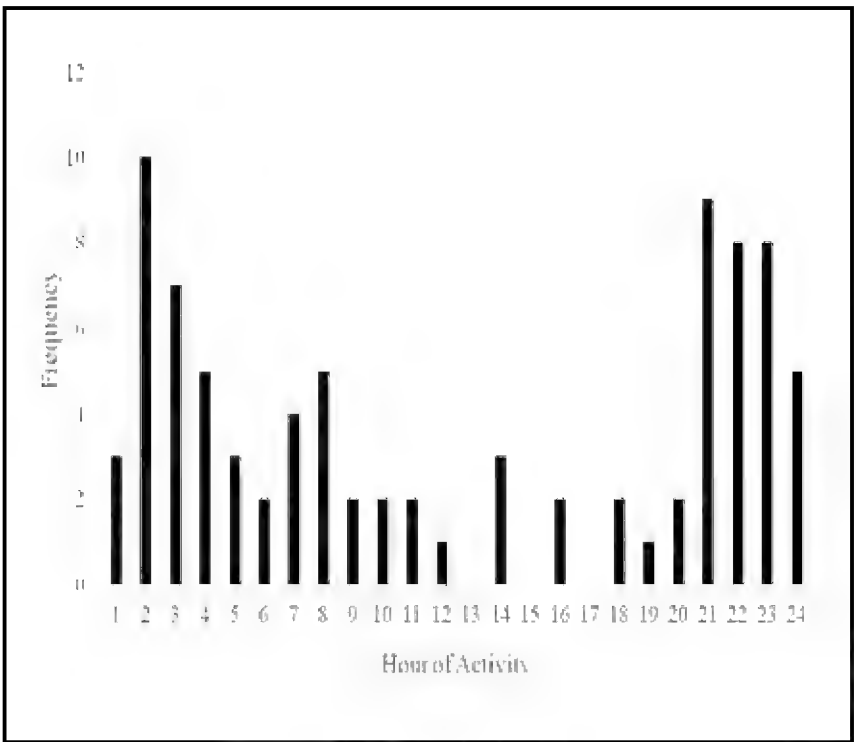


Figure 7. Frequency of camera trap observations of mammals and birds plotted against hour of activity.

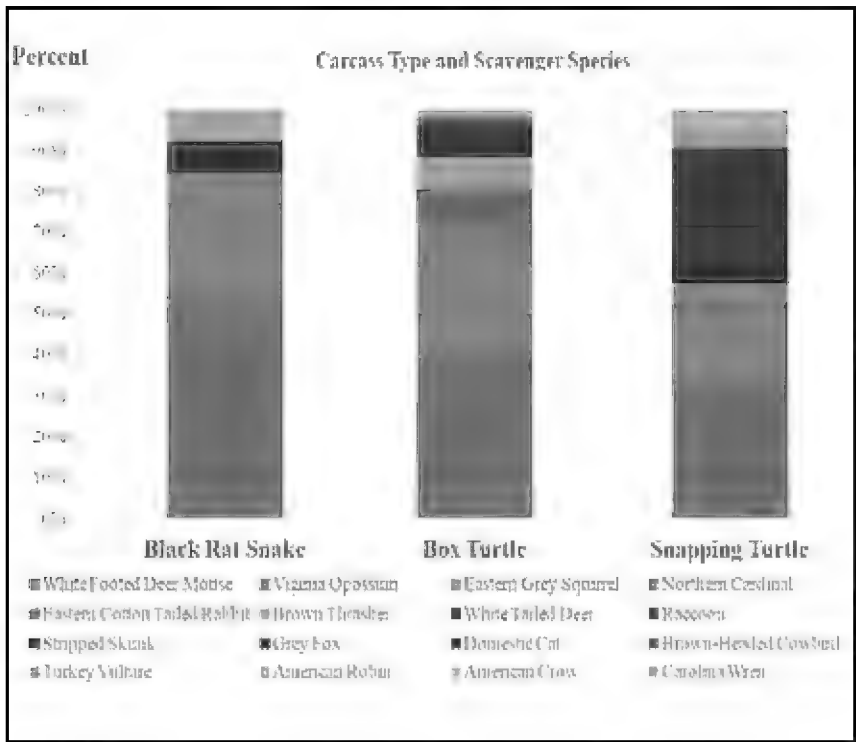


Figure 6. Percentage of scavenger species (vertebrates: birds and mammals) observed on individual carcass type.

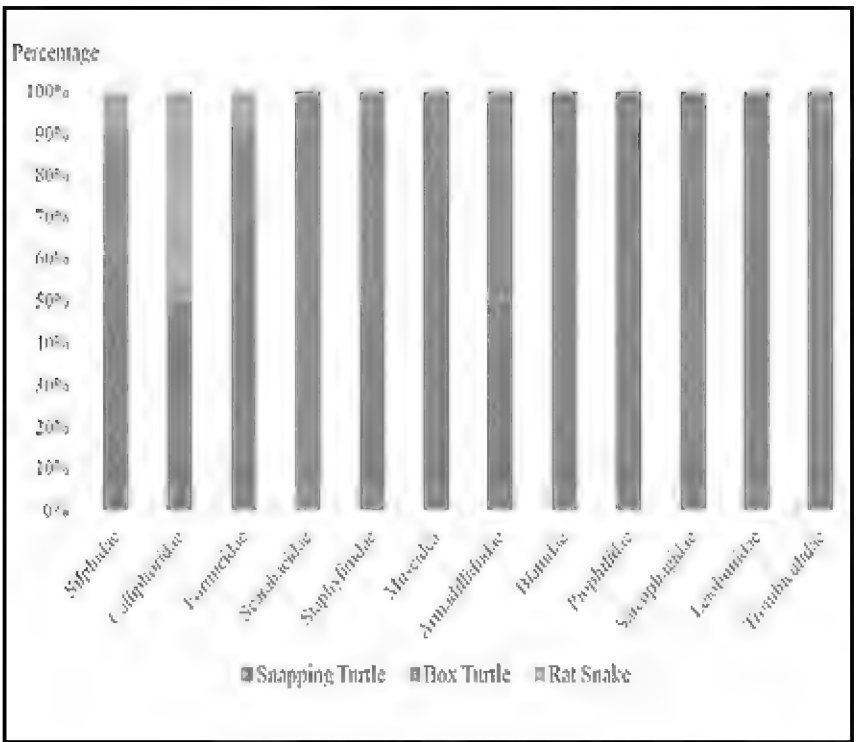


Figure 8. Relative frequencies of Insect families identified across carcass types.

Formicidae, with five insect families present on the box turtle: Silphidae, Formicidae, Muscidae, Staphylinidae, and Scarabaeidae. The snapping turtle carcass comprised the most amount of insect families represented by Silphidae, Staphylinidae, Psychodidae, Formicidae, Calliphoridae, Muscidae, Sarcophagidae, Stratiomyidae, and Blattidae (Table 1; Fig. 8). We observed adult and larval Coleopterans *Oiceoptoma inaequale* and *Oiceoptoma noveboracense* on both species of turtles (Figs. 9, 10), several Dipteran fly adults, including *Lucilia sericata* on the rat snake (Fig. 11), and *Musca domes-*

tica on snapping turtle (Fig. 12) when visiting carcasses and also identified in the insects we collected. Many of the *Oiceoptoma inaequale* adults we observed when visiting the rat snake carcass were breeding directly on and even in the carcass (Fig. 9). We first observed fly instars (maggots) on the box turtle and snapping turtle at day 7 and day 9, respectively, with none observed on the rat snake. In addition to insects, we further identified other arthropods present on carcasses, including 14 and 16 *Armadillium vulgare* (Order Isoptera, Family Armadillidiidae) on box turtle carcass and snap-

ping turtle carcass, respectively. Lastly we collected 3 harvestmen *Leiobunum* sp. (Order Opiliones, Family Leiobunidae) and 2 harvest mites *Trombicula* sp. (Order Trombidiformes, Family Trombiculidae) on the snapping turtle carcass. We observed an increase in arthropods collected on decomposition days 7–9 and 14–17 (Fig. 13). Shannon Diversity Index for identified insects across all carcasses was 1.797.

DISCUSSION AND CONCLUSIONS

This study detected a diverse set of organisms, both invertebrate and vertebrates, which differentially utilize reptile carcasses in a semi-forested ecosystem. Our most frequently sighted organism on camera traps, the white-footed deer mouse, is among smaller mammals encountered investigat-

ing and scavenging on carcasses (O'Brien et al., 2007). We also noted similar to other studies in urban wooded areas, raccoons and Virginia opossums visiting carcasses (DeVault et al., 2004; Hager et al., 2012). In addition, we observed our black rat snake carcass to be scavenged within a short period (6 days), as other studies have found snakes to be scavenged within 36 hours (Antworth et al., 2005). We detected several species of passerine birds and rodents, which other studies have documented to scavenge remains (Pokines & Pollock, 2018). Other studies on pig, *Sus scrofa* carcasses have observed high visitations by rodents as well as birds in the family Corvidae (Komar & Beattie, 1998). It is possible we detected several bird species other than the turkey vulture on camera traps that were attracted to the smell of the carcass or that were feeding on insects that were present on or near the carcass. Moreover,



Figures 9–12. Example of invertebrates colonizing carcasses, including *Oiceoptoma inaequale* on rat snake (Fig. 9), *Oiceoptoma noveboracense* larvae on box turtle (Fig. 10), *Lucilia sericata* on rat snake (Fig. 11), and *Musca domestica* on snapping turtle (Fig. 12).

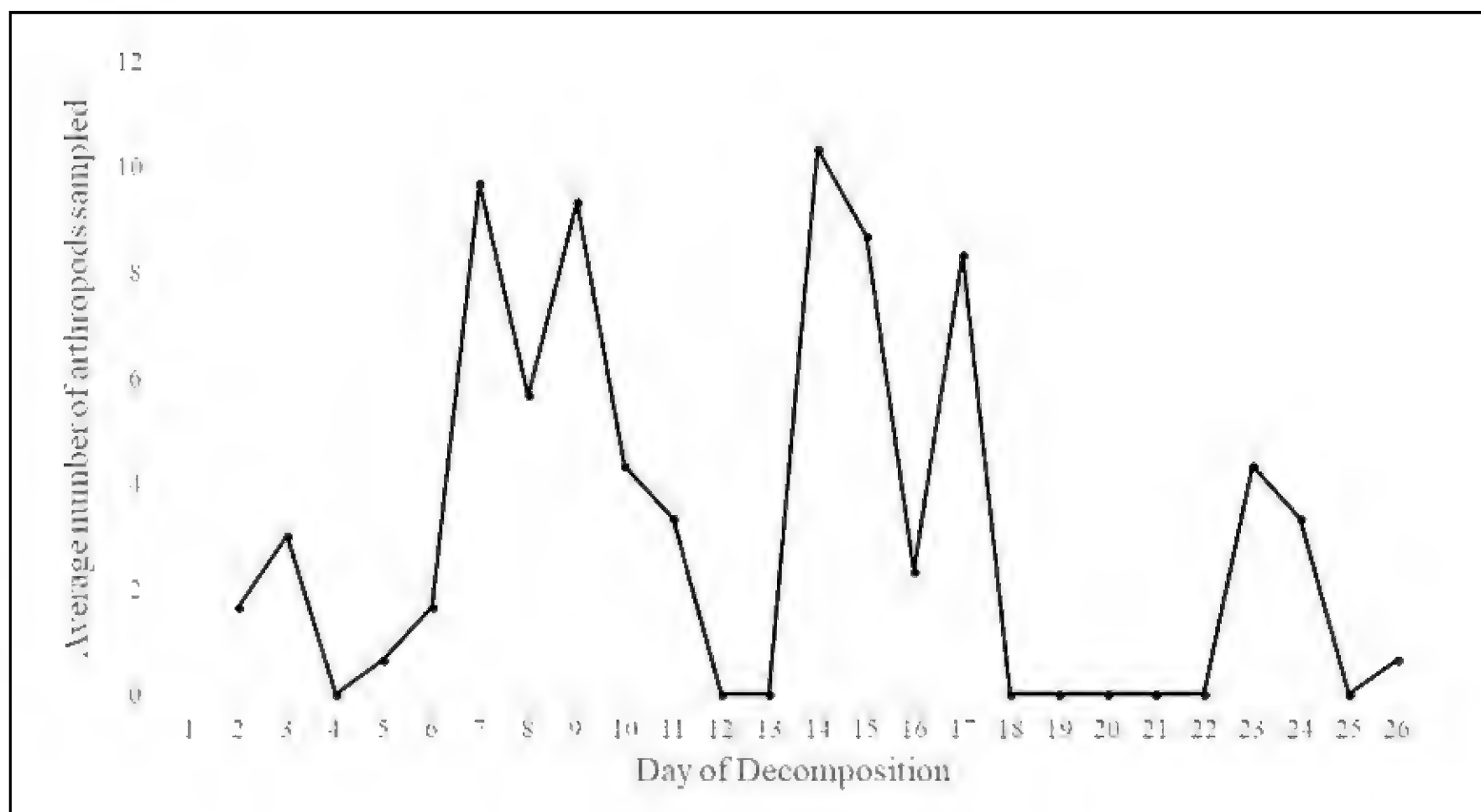


Figure 13. The average number of arthropods sampled across all carcass types during the experiment plotted against the day of decomposition. We noted an increase in arthropod activity within days 7–9 and 14–17.

we detected two separate taxonomic groupings of ants on carcasses, which can both directly consume carcasses material and affect colonization by other insects by lacerating carcasses (Eubanks et al., 2019).

We identified several groups of carrion-associated Coleoptera and Diptera across carcasses. The majority of carcasses were dominated by the presence of *Oiceoptoma* sp. adults and larvae and also insects from the Dipteran family Calliphoridae, both frequent colonizers of carrion (Michaud & Moreau, 2017). We observed many members of the insect family Piophilidae, which are forensically important necrophagous species used to estimate the postmortem interval in forensics (Rocheffort et al., 2015). Moreover, many of the Calliphoridae (blow flies) we detected, including *Lucilia sericata*, utilize carrion as breeding sites (Smith & Wall, 1997), and are typically found in high relative abundances on pig carcasses used in forensic entomology (Gruner et al., 2007). One of the few studies on insect colonization of reptiles using the American alligator, *Alligator mississippiensis*, found both adult and instars of Calliphoridae within the first 6 to 7 days of decomposition (Watson & Carlton, 2005b). We collected adult Cal-

liphoridae within the first 3 days of decomposition for two of our carcasses, the snapping turtle and rat snake. Our results for many of the invertebrate scavengers are similar to other studies (Cammack et al., 2016; Cruise et al., 2018), for many of the same indicator insect groups on porcine remains, although we did not detect the American carrion beetle *Necrophila americana*, on any of our carcasses, as it may be a late carcass colonizer (Watson & Carlton, 2005a). Interestingly, we also detected the Coleopteran *Platydracus* sp., which is suspected of preying on dipterans (Byrd & Castner, 2000) indicating the potential importance of carrion as a resource not only for insect egg deposition, but predation by other insects. Our observation of Dipteran instars on both turtle carcasses within 7 to 9 days after carcass deployment, indicate potentially several species of flies deposited offspring on carrion. We did not detect Dipteran or *Oiceoptoma* sp. larvae on the rat snake carcass, likely due to this carcass being scavenged completely and removed from our experiment by a scavenger (*D. virginiana*) on the seventh day of deployment, or possibly not enough time for development. However, in our visits to the snake carcass, we confirmed the presence of *Oiceoptoma* sp.

adults breeding near, on, and even inside the snake carcass (Fig. 9), which was also validated on at least one camera trap. This observation indicates the potential for future work utilizing camera traps to monitor not just bird and mammal vertebrates, but also smaller-sized insect colonizers of carrion, particularly as trail camera video and image quality improves and becomes more affordable to biologist documenting local biodiversity. For example, camera traps could be placed within ~0.25 m and set to record video and still photos at specific time intervals of a carcass to non-invasively identify insect colonizers and monitor frequency of visitations by adult insects.

The diversity of invertebrates and vertebrate scavengers present in our study represent dominant scavengers of not only reptiles but likely also other types of carrion in the local ecosystem. Furthermore, our observations for camera trap encounters, which occurred primarily nocturnally for mammals and during early mornings for birds, indicate activity patterns of scavengers, some of which were less abundant and seen less frequently on specific carcasses. Therefore, our data indicate that camera traps are effective for monitoring scavengers in semi-forested ecosystems and that reptile carrion is an essential resource in local food webs. In addition, using camera traps allows for the detection of animals that are more likely to flee from carrion as researchers approach carcasses to collect insects. Future work could incorporate further documentation of the micro-ecosystem and ecological cascade that forms around carrion. For example, as the number of insects colonizing a carcass increases, bird activity concomitantly increases due to the availability of invertebrate prey, in addition to scavenging by a variety of mammals.

The goal of this study was to provide preliminary data on reptile carcasses utilization as a carrion resource, which have been understudied in both forensic entomology and scavenging ecology. Our results on the snake carcass are limited due to it being scavenged and removed. Subsequently, future research should focus on examining the role of additional types of reptiles (e.g., lizards), and also increasing sample size to better understand if either insects or mammals colonize and scavenge reptiles similar to other carrion. Moreover, experimental carcasses could be deployed in protective cages to prevent removal by mammalian scavengers, as we observed

with the rat snake. We observed the greatest number of individual insects and family diversity on the snapping turtle carcass, possibly due to its overall larger size compared to the smaller box turtle and snake carcasses or due to this carcass being placed ~ 2 weeks prior to the box turtle and snake carcasses. However, our overall results across carrion types provide baseline information on many of the same insect orders which have been observed in other studies (Cammack et al., 2016), with waltzing flies, *Prochyliza* sp. (Diptera) and the carrion beetle *Oiceoptoma* sp. (Coleoptera) being dominant colonizers of reptile carrion. We conclude, based on our data observations, that reptile carrion may help maintain local biodiversity across trophic levels of both vertebrates and invertebrate communities, including a variety of insect, mammal, and bird species.

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REFERENCES

- Abernathy E.F., Turner K.L., Beasley J.C. & Rhodes O.E. Jr., 2017. Scavenging along an ecological interface: utilization of amphibian and reptile carcasses around isolated wetlands. *Ecosphere*, 8: 1–12.
- Andrews K.M., Gibbons J.W. & Jochimsen D.M., 2008. Ecological effects of roads on amphibians and reptiles: a literature review. In: *Urban Ecology*, Mitchell J.C., Brown R.R. J. & Bartholomew B., Society for the Study of Amphibians and Reptiles, pp. 121–143.
- Amendt J., Campobasso C.P., Guadry E., Reiter C., LeBlanc H.N. & Hall M.J.R., 2007. Best practices in forensic entomology-standards and guidelines. *International Journal of Legal Medicine*, 121: 90–104. <https://doi.org/10.1007/s00414-006-0086-x>
- Antworth R.L., Pike D.A. & Stevens E.E., 2005. Hit and Run: Effects of scavenging on estimates of roadkilled vertebrates. *Southeastern naturalist*, 4: 647–656.

- Beasley J.C., Olson Z.H. & Devault T.L., 2012. Carrion cycling in food webs: comparisons among terrestrial and marine ecosystems. *Oikos*, 121: 1021–1026. <https://doi.org/10.1111/j.1600-0706.2012.20353.x>
- Benecke M., 2001. A brief history of forensic entomology. *Forensic Science International*, 120: 2–14.
- Byrd J.H. & Castner J.L., 2000. *Forensic Entomology: the utility of arthropods in legal investigations*. CRC Press, Boca Raton, Florida, 705 pp.
- Cammack J.A., Cohen A.C., Kreitlow K.L. & Watson D.W., 2016. Decomposition of concealed and exposed porcine remains in the North Carolina Piedmont. *Journal of Medical Entomology*, 53: 67–75. <https://doi.org/10.1093/jme/tjv183>
- Carter D.O., Yellowlees D. & Tibbett M., 2007. Cadaver decomposition in terrestrial ecosystems. *Naturewissenschaften*, 94: 12–24. <https://doi.org/10.1007/s00114-006-0159-1>
- Cruise A., Watson D.W. & Schal C., 2018. Ecological succession of adult necrophilous insects on neonate *Sus scrofa domesticus* in central North Carolina. *PLoS ONE* 13, e0195785. <https://doi.org/10.1371/journal.pone.0195785>
- DeVault T.L., Brisbin I.L. & Rhodes O.E., 2004. Factors influencing the acquisition of rodent carrion by vertebrate scavengers and decomposers. *Canadian Journal of Zoology*, 82: 502–509.
- Eubanks M.D., Lin C. & Tarone A.M., 2019. The role of ants in vertebrate carrion decomposition. *Food Webs*, 18: e00109.
- Gruner S.V., Slone D.H. & Capinera J.L., 2007. Forensically important Calliphoridae (Diptera) associated with pig carrion in rural north-central Florida. *Journal of Medical Entomology*, 44: 509–515.
- Hager S.B., Cosentino B.J. & McKay K.J., 2012. Scavenging affects persistence of avian carcasses resulting from window collisions in an urban landscape. *Journal of Field Ornithology*, 83: 203–211.
- Haxton T., 2000. Road mortality of snapping turtles, *Cheyledra serpentina*, in central Ontario during their nesting period. *Canadian Field Naturalist*, 114: 106–110.
- Inger R., Cox D.T.C., Per E., Norton B.A. & Gaston K.J., 2016. Ecological role of vertebrate scavengers in urban ecosystems in the UK. *Ecology and Evolution*, 6: 7015–7023. <https://doi.org/10.1002/ece3.2414>
- Komar D. & Beattie O., 1998. Identifying bird scavenging in fleshed and dry remains. *Canadian Society of Forensic Science Journal*, 31: 177–188. <https://doi.org/10.1080/00085030.1998.1075117>
- Kreitlow K., 2010. Insect succession in a natural environment. In: Byrd J.H. & Castner J.L., *Forensic Entomology: The Utility of Arthropods in legal investigations*. CRC Press, Boca Raton, Florida, 251–270.
- Kulshrestha P. & Satpathy D.K., 2001. Use of beetles in forensic entomology. *Forensic Science International*, 120: 15–17.
- Melis C., Teurlings I., Linnell J.D.C., Andersen R. & Bordoni A., 2004. Influence of deer carcass on Coleopteran diversity in a Scandinavian boreal forest: a preliminary study. *European Journal of Wildlife Research*, 50: 146–149. <https://doi.org/10.1007/s10344-004-0051-2>
- Michaud J. & Moreau G., 2017. Facilitation may not be an adequate mechanism of community succession on carrion. *Oecologia*, 183: 1143–1153. <https://doi.org/10.1007/s00442-017-3818-3>
- O'Brien R.C., Forbes S.L., Meyer J. & Dadour I.R., 2007. A preliminary investigation into the scavenging activity on pig carcasses in Western Australia. *Forensic Science, Medicine and Pathology*, 3: 194–199.
- Perez A.E., Haskell N.H. & Wells J.D., 2016. Commonly used intercarcass distances appear to be sufficient to ensure independent of carrion insect succession pattern. *Annals of the Entomological Society of America*, 109: 72–80.
- Pokines J. & Pollock C., 2018. The small scavenger guild of Massachusetts. *Forensic Anthropology*, 1: 52–67. <https://doi.org/10.5744/fa.2018.0005>
- Pomezanski D. & Bennett L., 2018. Developing recommendations for monitoring wildlife underpass usage using trail cameras. *Environmental Monitoring and Assessment*, 190: 413. <https://doi.org/10.1007/s10661-018-6794-0>
- Rocheft S., Giroux M., Savage J. & Wheeler T.A., 2015. Key to the forensically important Piophilidae (Diptera) in the Nearctic region. *Canadian Journal of Arthropod Identification*, 27: 1–37. <https://doi.org/10.3752/cjai.2015.27>
- Row J.R., Blouin-Demers G. & Weatherhead P.J., 2007. Demographic effects of road mortality in Black rat snake (*Elaphe obsoleta*). *Biological Conservation*, 137: 117–124. <https://doi.org/10.1016/j.biocon.2007.01.020>
- Schlichting P.E., Love C.N., Webster S.C. & Beasley J.C., 2019. Efficiency and composition of vertebrate scavengers at the land-water interface in the Chernobyl Exclusion Zone. *Food Webs*, 18: e00107. <https://doi.org/10.1016/j.fooweb.2018.e00107>
- Schwartz A.L.W., Williams H.F., Chadwick E., Thomas, R.J. & Perkins S.E., 2018. Roadkill scavenging behavior in an urban environment. *Journal of Urban Ecology*, 4: 1–7.
- Shannon G., Lewis J.S. & Gerber B.D., 2014. Recommended survey designs for occupancy modeling using motion-activated cameras: insights from empirical wildlife data. *PeerJ*, 2:e532. <https://doi.org/10.7717/peerj.532>

- Schoenly K.G., Haskel N.H., Mills D.K., Bieme-Ndi C., Larsen K. & Lee Y., 2006. Recreating death's acre in the school yard. Using pig carcasses as model corpses to teach concepts of forensic entomology and ecological succession. *American Biology Teacher*, 68: 402–410. [https://doi.org/10.1662/0002-7685\(2006\)68\[402:RDAITS\]2.0.CO;2](https://doi.org/10.1662/0002-7685(2006)68[402:RDAITS]2.0.CO;2)
- Smith K. & Wall R., 1997. The use of carrion as breeding sites by the blowfly *Lucilia sericata* and other Calliphoridae. *Medical and Veterinary Entomology*, 11: 38–44.
- Smith L.L. & Dodd C.K., 2003. Wildlife mortality on U.S. highway 441 across Paynes prairie, Alachua county, Florida. *Florida Scientist*, 66: 128–140.
- VanLaerhoven S.L. & Anderson G.S., 1999. Insect succession on buried carrion in two biogeoclimatic zones of British Columbia. *Journal of Forensic Science*, 44: 32–43.
- Watson E.J. & Carlton C.E., 2005a. Succession of forensically significant carrion beetle larvae on large carcasses (Coleoptera: Silphidae). *Southeastern Naturalist*, 4: 335–346. [https://doi.org/10.1656/1528-7092\(2005\)004\[0335:SOFSCB\]2.0.CO;2](https://doi.org/10.1656/1528-7092(2005)004[0335:SOFSCB]2.0.CO;2)
- Watson E.J. & Carlton C.E., 2005b. Insect succession and decomposition of wildlife carcasses during fall and winter in Louisiana. *Journal of Medical Entomology*, 42: 193–203. [https://doi.org/10.1603/0022-2585\(2005\)042\[0193:ISADOW\]2.0.CO;2](https://doi.org/10.1603/0022-2585(2005)042[0193:ISADOW]2.0.CO;2)

A revision of the Mediterranean Raphitomidae, 8: on two poorly known species of *Raphitoma* Bellardi, 1847: *R. pumila* (Monterosato, 1890) and *R. hispidella* nomen novum (Gastropoda Conoidea)

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ABSTRACT

Two poorly known species of genus *Raphitoma* Bellardi, 1847 (Gastropoda Conoidea) are revised. *Raphitoma pumila* (Monterosato, 1890) is redescribed and *Cordieria cordieri* var. *hispidella*, Monterosato, 1890 is raised to species level and transferred to the genus *Raphitoma*, hence requiring the creation of a replacement name (*R. hispidella* nomen novum) due to secondary homonymy with *R. hispidella* Bellardi, 1877.

KEY WORDS

Raphitomidae; revision; taxonomy; nomen novum.

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INTRODUCTION

The Raphitomidae are currently considered as a well-supported clade of the Conoidea (Bouchet et al., 2011), worthy of family ranking. It is probably the most diverse family of Conoidea, in terms of species richness, ecological range and anatomical disparity (Kantor & Taylor, 2002), and are therefore considered as potentially ideal candidates for toxin discovery (Puillandre et al., 2017).

We are currently revising the Raphitomidae of the Mediterranean Sea and adjacent Atlantic coasts. We provisionally estimated ca. 50 Mediterranean extant species, some of which still undescribed. The taxon Raphitomidae Bellardi, 1875 is based on the genus *Raphitoma* Bellardi, 1847 which was introduced as comprising 34 fossil and recent species (Bellardi 1847: 85), previously classified in various genera (such as *Pleurotoma* and *Clathurella*).

During this revision, we have found a quite rare species of *Raphitoma* described by Monterosato (1890) as a variety of the so called *Cordieria reticulata* (= *Raphitoma echinata*). In our opinion it is a good species having its own peculiar characteristics

MATERIAL AND METHODS

Our approach was exclusively based on shell morphology due to the almost total lack of anatomical data.

Specimens studied come from private collections (see Abbreviations).

Light photographs were taken (if not otherwise stated) by Stefano Bartolini using a Canon EOS 400D digital photcamera, with standard objective 50 mm + adapted lens (25 and 12.5 mm) for 16

and 8 mm vintage cine camera and by Yves Lafontaine.

ABBREVIATIONS AND ACRONYMS. BAR: Stefano Bartolini Firenze, Italy; BOG: Cesare Bogi (Livorno, Italy); CHI: Francesco Chiriacco (Livorno, Italy); CRO: Paolo Crovato (Napoli, Italy); LAF: Yves Lafontaine (Fréjus, France); MCZR: Museo Civico Zoologia, Roma, Italy; MRSNT: Museo Regionale Storia Naturale, Terrasini (Palermo, Italy); OZT: Bilal Oztürk (Izmir, Turkey); PAG: Attilio Pagli (Lari, Italy); PAO: Paolo Paolini (Livorno, Italy); PIS: Michele Pisanu (Cagliari, Italy); PKR: Jakov Prkić (Split, Croatia); PUS: Francesco Pusateri (Palermo, Italy); QUA: Ermanno Quaggiotto (Vicenza, Italy); RON: Francesco Roncone (Cosenza, Italy); SMR: Carlo Smriglio (Roma, Italy); SPA: Maria Teresa Spanu (Alghero, Italy). H/W: height/width ratio; SD: Standard Deviation; sh/s: shell/s.

***Raphitoma pumila* (Monterosato, 1890)**
(Figs. 1–7)

Pleurotoma (Homotoma) reticulata var. *pumila* Monterosato, 1878: 106 (nomen nudum)
Cordieria reticulata var. *pumila* Monterosato, 1890: 187
Cordieria pumila Appolloni et al., 2018: 66

ORIGINAL DIAGNOSIS. Monterosato (1890): “*Cordieria reticulata* var. *pumila* Monts. - Più corta; si direbbe una forma nana, spesso incolore, reticolazione più fitta, bocca fortemente dentata - Funnazzi, Algeria, Lipari etc.” (shorter; it would seem a dwarf form, often colorless, denser cross-linking, strongly toothed mouth - Funnazzi, Algeria, Lipari etc.)

TYPE MATERIAL. MCZR-M 16774: Lectotype from Algeria (14 x 6.3 mm, labelled “*tipo*”) and paralectotypes from Palermo (16.7 x 7.8 mm and 14.3 x 7.5 mm). According the ICZN art. 72.4.7 the term “*tipo*” of the labels is not necessarily an evidence that this specimen is the “holotype”. However we respect the indication of Monterosato and fix this specimen as a lectotype.

TYPE LOCALITY. Algeria.

EXAMINED MATERIAL. The type material and: France. Saint-Raphaël, port du Poussaï, Le Dramont, 1 sh (LAF).

Italy. Sardinia: La Maddalena, 1 sh (SPA). Sicily: No locality, 1 sh (MCZR-M 16903); Mare di Sicilia, 1 sh (MRSNT n. 29823), sub nomine *R. reticulata*; Ficcarazzi, 2 shs (PUS); Brucoli, 1 sh (PUS).

Morocco. Alboran Sea, 1 sh (PUS).

Algeria. No locality, 1 sh (SPA).

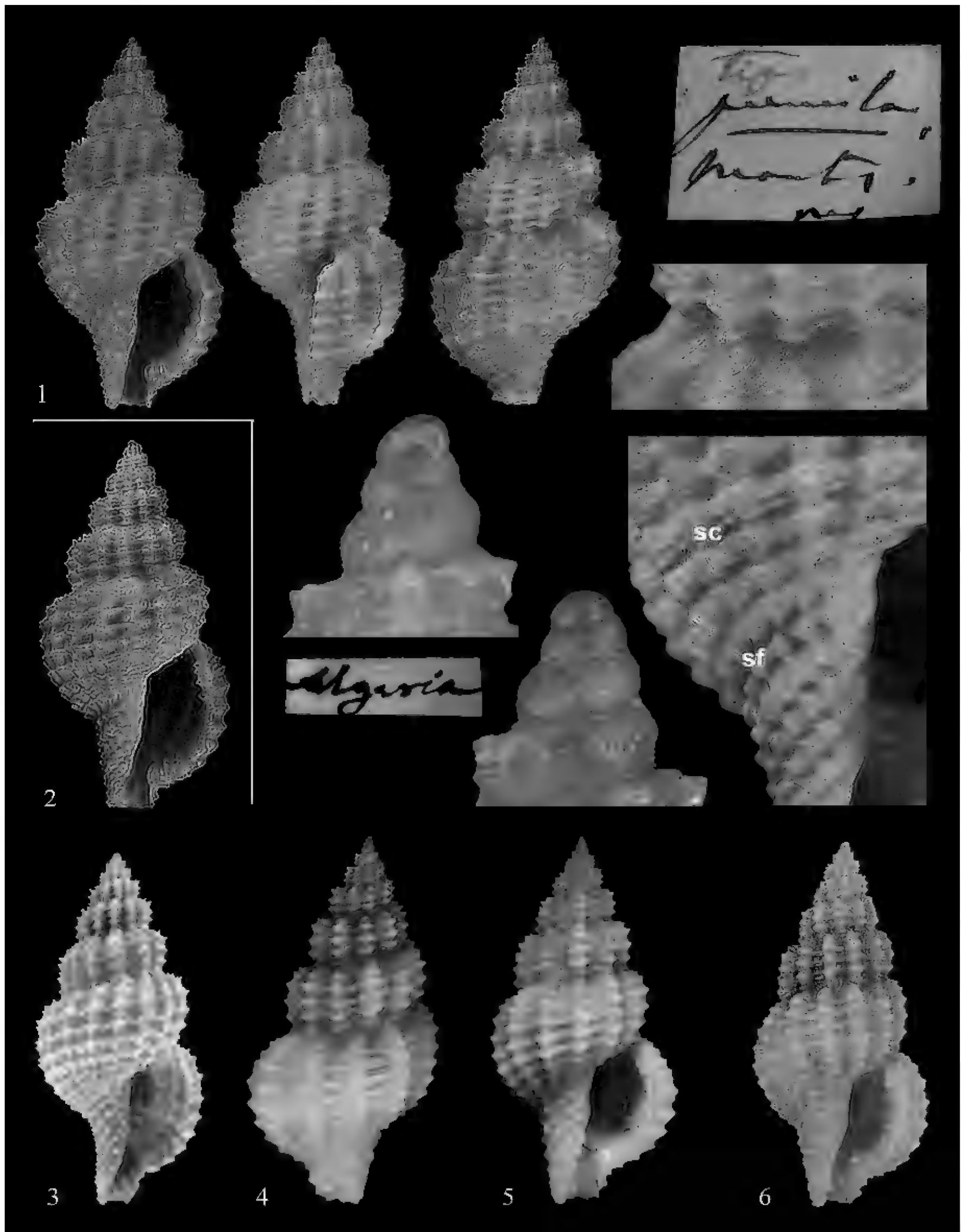
DESCRIPTION. In square brackets the data of the holotype. Shell biconic squat, of medium size for the genus, height: 9–17 mm, mean: 13.9, SD: 2.41 [14]; width: 5–8.6 mm, mean: 6.9, SD: 1.12 [6.3]; H/W: 1.91–2.22, mean: 2.02, SD: 0.11 [2.22].

Protoconch multispiral, rust brown in colour, of 2.75 convex whorls, height 483 µm, width 460 µm, protoconch I of 1.1 whorls, covered by thin cancellations, protoconch II with a diagonally cancellated sculpture starting after a zone under the suture with fine axial threads. The last whorl shows a keel before the onset of the teleoconch. Protoconch-teleoconch boundary slightly flexuose, opisthocline. Teleoconch of 5.5–7.5 [6.5] rounded whorls, stout, suture incised, sculpture robust. Densely disseminated microgranules in the surface. Axial sculpture of 14–18 [16] orthocline (occasionally slightly opisthocline or prosocline), equidistant ribs, and interspaces larger than the ribs in the last whorl, narrower in the others. Spiral sculpture above the aperture of 5 to 6 [6] cordlets. Sometime 1 or 2 supplementary small cordlets can occur. Cancellation rectangular, with strong, elongated and acute tubercles at the intersections. Subsutural ramp large, with one or two small spiral cordlets. Columella simple, slightly sinuous anteriorly. Outer lip thick with 9–12 strong inner denticles [12], the 2 most anterior more robust and delimiting the short but wide and conical siphonal canal. Siphonal fasciole with 6–9 [7] nodulose cords with first 3 more strong. Colour uniformly light straw sometime with a pale brownish band around the suture and on the low part of the last whorl. Occasionally comma-shaped white spots on the subsutural ramp. Sometime there are whitish chevron among axial ribs of the last whorl.

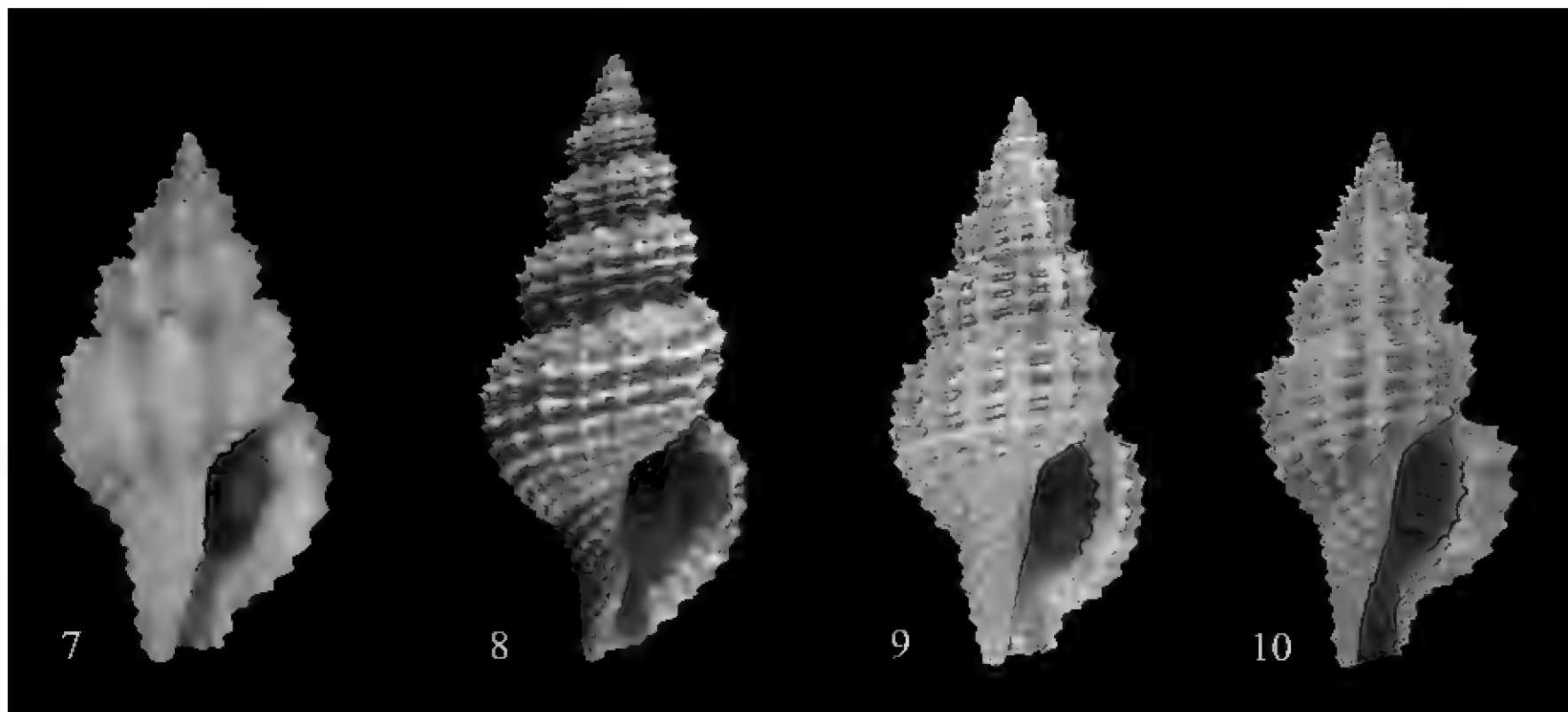
Soft parts unknown.

DISTRIBUTION. This quite rare species seems to occur only in the Western and Central Mediterranean.

COMPARATIVE NOTES. This species is quite similar to one of the morphotypes of *R. echinata* (Brocchi, 1814) (Figs. 8–10) but differs having a lower



Figures 1–6. Shells of *Raphitoma pumila* (Monterosato, 1890). Fig. 1: Lectotype, Algeria (MCZR-M-16774), h: 14 mm with 2 original labels, particular of subsutural zone, particular of the secondary cordlet (sc) and of the starting point of siphonal fasciole (sf), and protoconch (2 view). Fig. 2: type B, Palermo (Italy), (MCZR-M-16774), h: 14.3. Fig. 3: Algeria, h: 14 mm. Fig. 4: St. Raphael (France), h: 9.6 mm. Fig. 5: St. Raphael (France), h: 9.8 mm. Fig. 6: Castiglioncello, Livorno (Italy), h: 12 mm. Figs. 4, 5: photos courtesy by Gilles Devauchelle.



Figures 7–10. *Raphitoma pumila* (Monterosato, 1890). Fig. 7: S. Raphael (France), h: 11 mm. Figs. 8–10: shells of a morphotype of *Raphitoma echinata* AA. Fig. 8: Channel of Hvar (Croatia), h: 21.1 mm. Fig. 9: Costa del Sol (Spagna), h: 15 mm. Fig. 10: Montecristo Island (Italy), h: 8.3 mm.

H/D, apical angle wider, more stout axial ribs, last whorl lower, outer lip thicker, the shorter siphon and having a less inclined suture.

REMARKS. This species introduced by Monterosato (1878: *nomen nudum*) was validated by Monterosato itself (1890) who gave a short but clear description.

Raphitoma hispidella Pusateri et Giannuzzi-Savelli nomen novum

Cordieria cordieri var. *hispidella*, Monterosato, 1890: 187, non *Raphitoma hispidella* Bellardi, 1877

Cordieria hispidella, Appolloni et al., 2018: 65, figs. 22 O-P

Raphitoma echinata sensu Manousis et al. 2018: 27 fig. 21c

ORIGINAL DIAGNOSIS. Monterosato (1890): “*C. cordieri*, Payr. (*Pleurot.*) - Una piccola forma che può distinguersi come: Var. *hispidella*, Monts. - A scultura *hispidella* e pungente; molto più piccola del tipo, un terzo. Gli esemplari freschi sono trasparenti e color di ambra. L’apice a (sic!) molti giri torricolati e punteggiati. Nella *C. reticulata* è revoluto”.

TYPE MATERIAL. Lectotype here designated, MCZR-M-17442 (10 x 4.4 mm) and 4 paralecto-

types (2 probably referred to *R. brunneofasciata* and 2 juveniles) with handwritten labels by Monterosato: *C. hispidella* Monts/ms.”, “*H. hispidella*, Monts./mss./Palermo, profonda/Si trova anche nell’Atlantico ad Arcachon (De Boury). (Da non confondere/con *hispidula* Brocc.)”.

TYPE MATERIAL. MCZR-M-17442 - 3 shs labelled: *H. hispidella* Monts. Palermo”; 2 shs labelled: *hispidella* Monts. Palermo comunicat.” // “Atlantico ad Arcachon (De Boury). (Da non confondere con *hispidula* Brocc.” // *C. hispidella* Monts Med”.

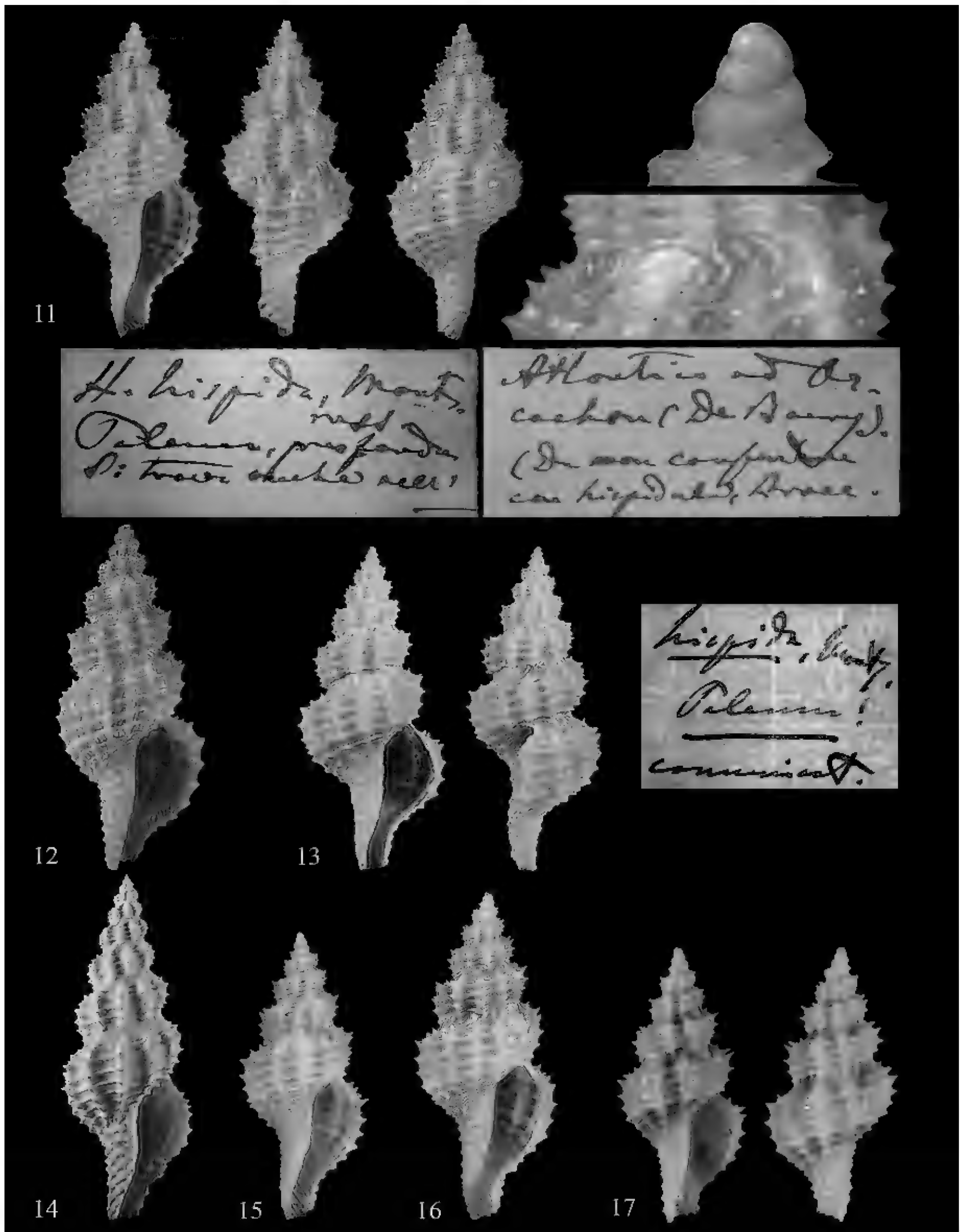
TYPE LOCALITY. Palermo.

EXAMINED MATERIAL. The type material and: Atlantic. France. Capbreton (Nouvelle Aquitaine), MCZR-M-17442 with handwritten label by Monterosato: “Cap Breton/De Folin” 1 sh. Portugal. Algarve, 5 shs (PUS).

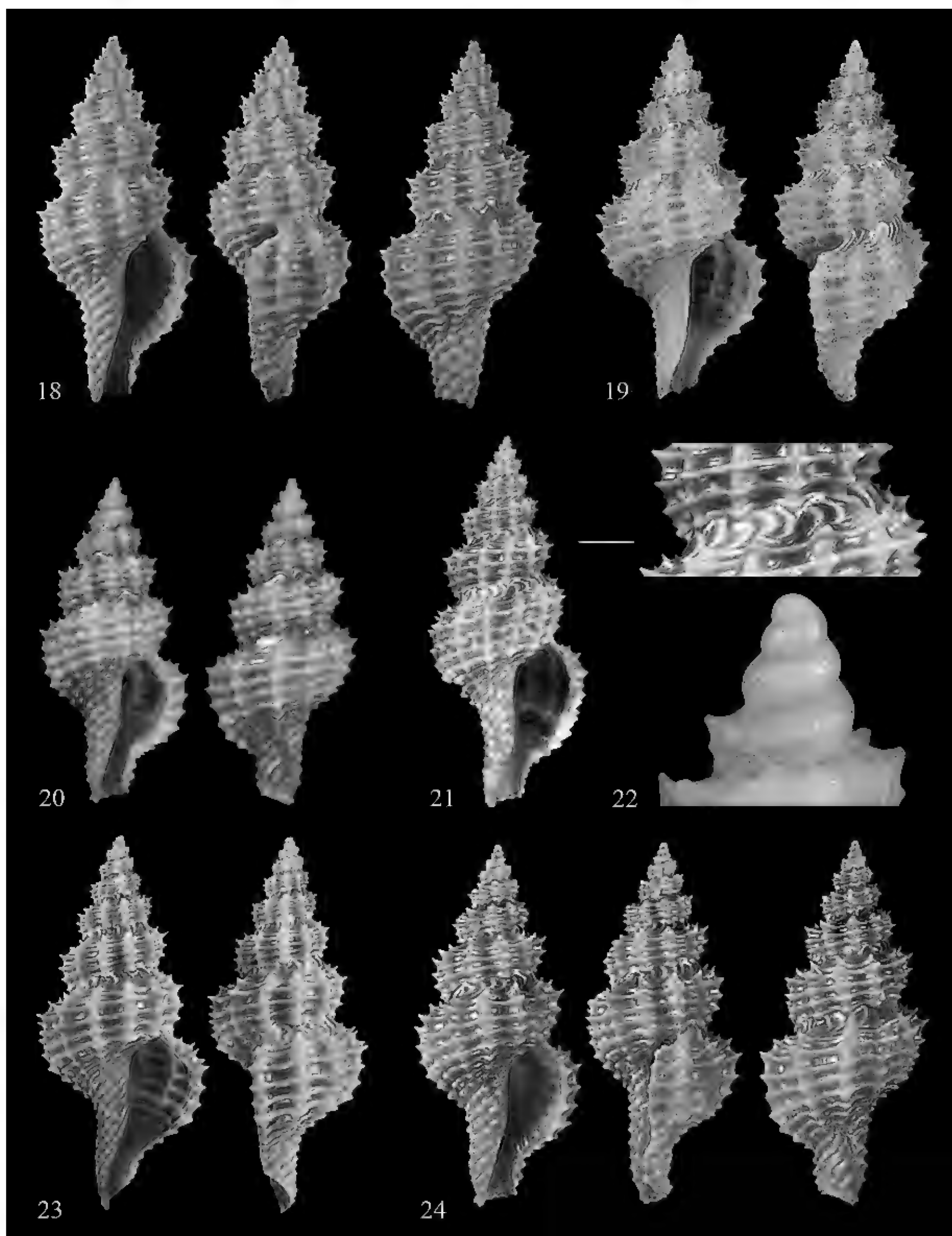
Mediterranean. Alboran, 1 sh (PUS). Spain. Barcelona, 1 sh (PAG).

Corse. Bastia, 2 sh (PAG); idem, 3 shs -50 m (MCZR-M-17442) sub nomine *Pl. cordieri*.

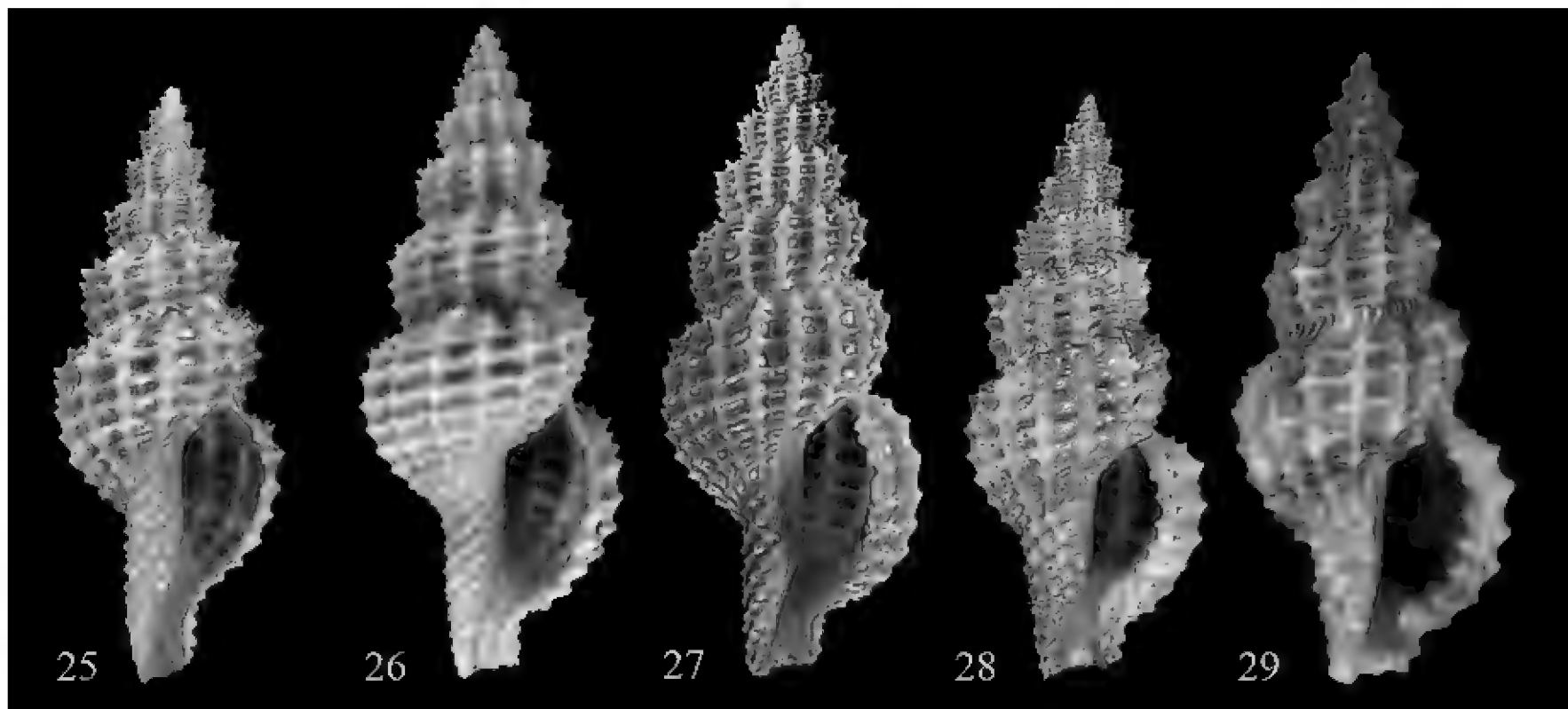
Italy. Isola d’Elba, 1 sh (PUS); Capo Enfoia, Isola d’Elba (Portoferraio, Toscana), -6 m, 5 shs (PAO); Secca delle Vedove -130, about 20 miles SW Gorgona Island (Tuscany Arch.), 2 shs (PAO); Antignano (Livorno), 1 sh (PAG); Castiglione (Livorno), 1 sh (BOG); Calambrone (Pisa) -30 m, 1 sh (BAR); Golfo di Baratti (Piombino, Livorno),



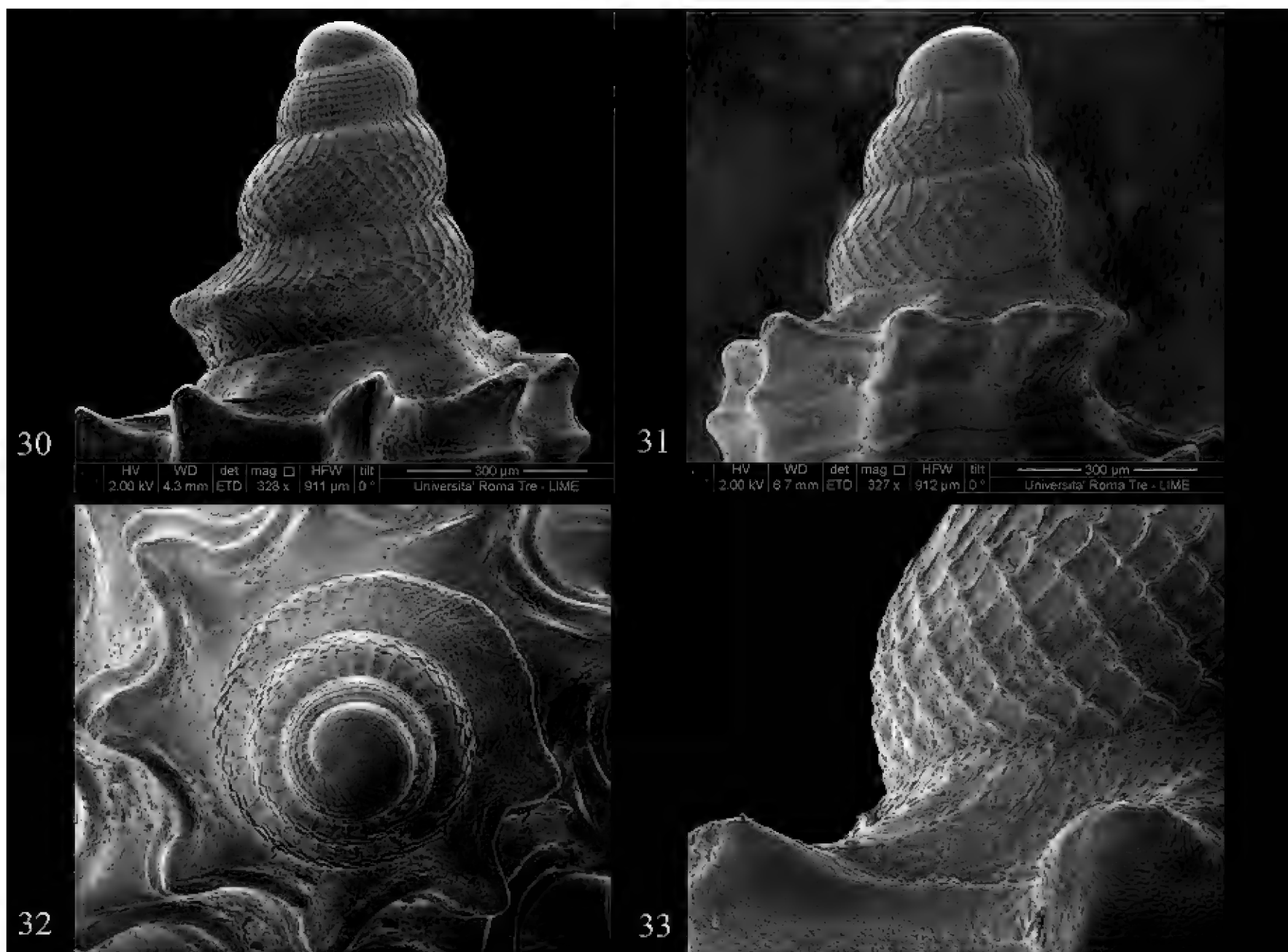
Figures 11–17. *Raphitoma hispidella* Pusateri et Giannuzzi-Savelli nomen novum. Fig. 11: Lectotype, Palermo (Italy), MCZR-M-17442, h: 10 mm, with original label (recto/verso), protoconch and particular of subsutural zone. Fig. 12: Napoli (Italy), MCZR-M-17442, h: 12.8 mm. Fig. 13: Palermo (Italy), MCZR-M-16476, h: 8 mm, with original label. Fig. 14: Rab Island (Croatia), -80 m, h: 11.8. Fig. 15: Rab Island (Croatia), h: 6.5 mm. Fig. 16: Rab Island (Croatia), h: 9 mm. Fig. 17: Güllük Bay (Turkey), -44 m, h: 5.5 (photo courtesy by Bilal Oztürk).



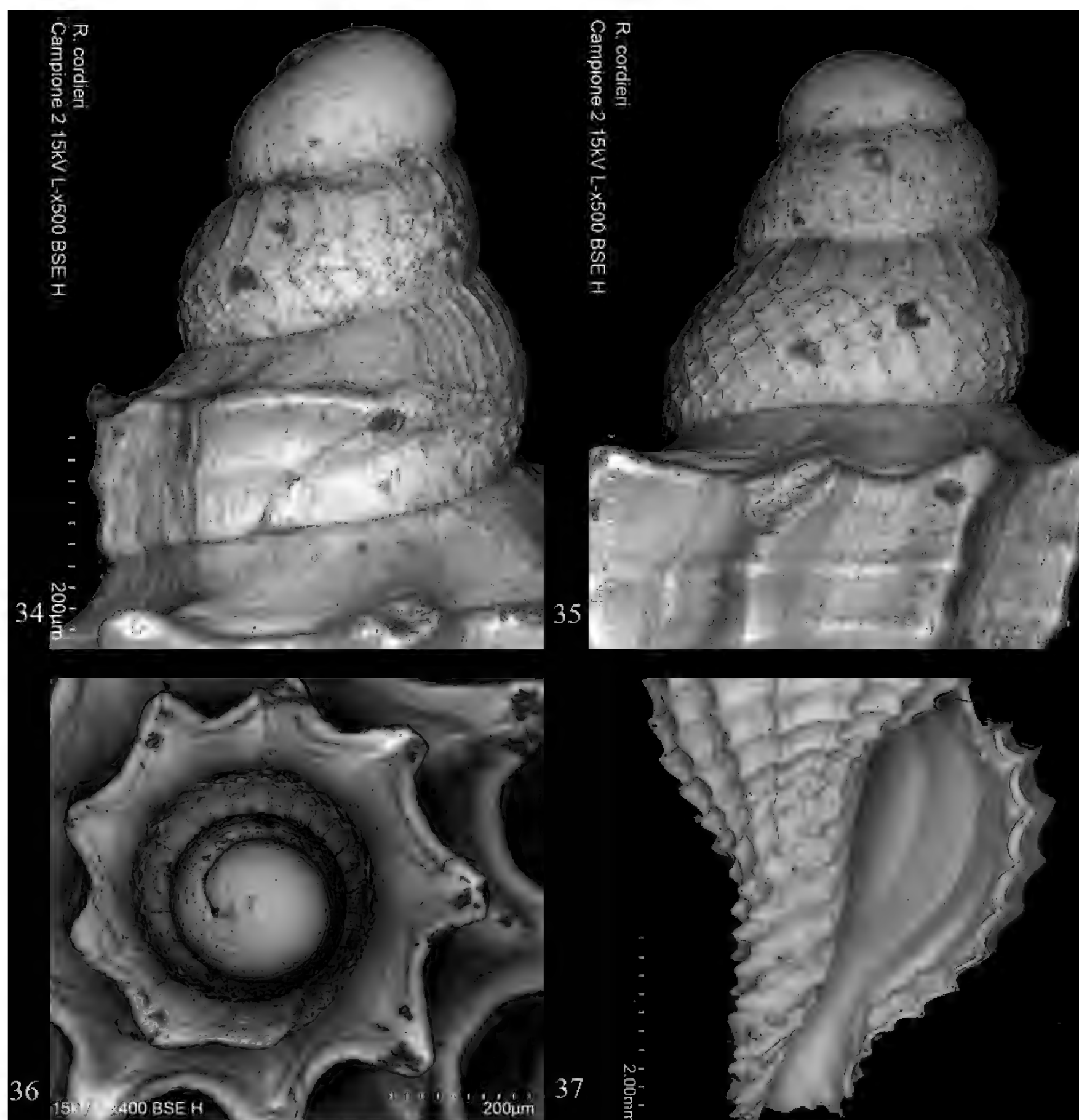
Figures 18–24. *Raphitoma hispidella* Pusateri et Giannuzzi-Savelli nomen novum. Fig. 18: Sant'Antioco Island (Carbonia-Iglesias, Italy), h: 9.5 mm. Fig. 19: Elba Island (Tusca Archipelago, Italy), h: 9.5 mm. Fig. 20: Isola delle Femmine (Palermo, Italy), h: 9.1 mm. Fig. 21: Aci Trezza (Catania, Italy), - 80 m, h: 15 mm, with particular of subsutural zone. Fig. 22: protoconch from the specimen of figure 15. Fig. 23: Circeo (Latina, Italy), -90, h: 11.3 mm. Fig. 24: Cagliari (Italy), h: 9.1 mm.



Figures 25–29. Fig. 25: *Raphitoma hispidella* Pusateri et Giannuzzi-Savelli nomen novum. Calambrone (Pisa, Italy), -30 m, h: 11.5 mm; Fig. 26: *Raphitoma cordieri* AA., Alghero (Sassari, Italy), h: mm 23.7; Fig. 27: *Raphitoma cordieri* AA., Napoli (Italy), h: 21 mm; Fig. 28: *Raphitoma echinata* AA., Saronikos (Greece), h: 9.2 mm; Fig. 29: *Raphitoma horrida* (Monterosato, 1884), Palermo (Italy), h: mm 12.



Figures 30–33. *Raphitoma hispidella* nomen novum, protoconch. Fig. 30: frontal view. Fig. 31: dorsal view. Fig. 32: apical view. Fig. 33: protoconch/teleoconch boundary with microgranules.



Figures 34–37. *Raphitoma cordieri* AA. Fig. 34: protoconch in frontal view. Fig. 35: protoconch in dorsal view. Fig. 36: protoconch in apical view. Fig. 37: siphonal fasciole.

-5 m, 4 shs (PAO); Fiumicino (Roma) -160 m., 1 sh (SMR); S. Felice Circeo (Latina), 1 sh (SMR); Napoli, 1 sh (MCZR-M-17442 sine nomine with Monterosato's label "non è *cordieri*!"); Cetraro (Cosenza), 1 sh (RON); Civitanova Marche (Macerata), 1 sh (CRO); Ortona (Chieti), 2 shs (QUA); S. Benedetto del Tronto (Ascoli Piceno), -80 m, 2 shs (PAO), 2 shs -80 m (BOG). Sardinia: Cagliari, 1 sh (PIS). Sicily: Ficcarazzi, 3 shs (PUS); Palermo, 1 sh (MCZR-M-16476) sub nomine *C. cordieri*;

Isola delle Femmine (Palermo), 3 shs (PUS), 1 sh (CRO); Acicastello (Catania), -100, 2 shs (PUS); Acitrezza (Catania), -80, 1 sh (CHI); Brucoli (Siracusa), 1 sh (PUS).

Tunisia. Djerba, 1 sh (PUS).

Croatia. Supetar (Brac Island), 1 sh (PAG); Veli Rat (Dugi Otok Island), 1 sh (PUS); Rab Island, 4 shs (BAR); Dubrovnik, 1 sh (PKR).

Turkey. Güllük Bay (Aegean Sea), 2 shs (OZT).

DESCRIPTION. In square brackets the data of the lectotype. Shell fusiform, of medium size for the genus, height 7–16.5 [10] mm, mean: 10.8, DS: 2.98 [10]; width 3.3–6.6 mm, mean: 4.76, DS: 1.17 [4.4]; H/W 2.12–2.47, mean 2.25, DS: 0.11 [2.27]. Teleoconch of 5.5–7 [6] convex whorls, fusiform and thin, suture thin, sculpture raised. Scattered microgranules in the surface of part of the first teleoconch whorl. Axial sculpture of 11–14, mean: 12, DS: 0.98 [13] orthocline, equidistant ribs, and interspaces three times wider than the ribs. Spiral sculpture of 5–6 mean [5] cordlets thinner than the axial ribs, above the aperture. Cancellation rectangular, with strong and slightly acute spines at the intersection of axials and spirals. Subsutural ramp wide, inclined and slightly arched. Columella simple, “s” slightly sinuous or almost straight anteriorly, angled posteriorly. Siphonal channel long and open that sometime can be twisted. Outer lip thin with 9–12 mean 10 [peristome not complete] weak inner lirate denticles. Siphonal fasciole with 8–9 cords [8]. Colour variable from uniformly yellow straw in the background (from light to dark), up to bright brown. On the last whorl is present a darker subsutural band. Comma-shaped white spots on the darker subsutural ramp. Entirely white specimens are known. The darker specimens are typical in the coralligenous biocenosis.

Soft parts unknown.

DISTRIBUTION. Mediterranean Sea and Atlantic coasts of Portugal, Spain and France in the circalittoral zone.

REMARKS. *Cordieria cordieri* var. *hispidella* Monterosato, 1890 is a valid taxon, which we deem deserving the rank of a species (and is an available name under art. 45.6.4 of the ICZN), although belonging to the genus *Raphitoma*, hence *Raphitoma hispidella* (Monterosato, 1890) n. comb. The new combination makes the name *hispidella* Monterosato, 1890 a secondary homonym (ICZN art. 59) of *R. hispidella* Bellardi, 1877 (see Bellardi, 1877) so a new name is necessary and we propose *hispidella* nomen novum, diminutive adjective of the Latin word “*hispidus*”.

In the original description Monterosato (1890) compares this “variety” with *Cordieria reticulata* (= *Raphitoma echinata*) stating that this has a “revolute apex” (paucispiral). A rather surprising statement because Monterosato (1884: 131) describes it instead with “*apice conico, acutissimo, composto*

di tre giri di spira punteggiati” (conical apex, very acute, composed of three punctuated whorls).

We believe this so-called variety is a good species. It differs constantly, without intermediates, by *R. cordieri* (Payraudeau, 1826) for: always smaller dimensions (max 16.3 vs. 25); very large and arched subsutural ramp vs. large and inclined; different size of protoconch (600 x 509 µm vs. 475 x 350 µm) and different number of whorls (3 vs 2.3); for their yellow straw/witish protoconch vs. milk white; more bristly and scaled profile versus less brittle and regular; shorter and open siphonal channel; lack of supplementary cordlets sometimes present in *R. cordieri*; rectangular cancellations vs. subquadrate; siphonal fasciole with less strong and closer nodules; siphonal fasciole with 8–9 nodulose cordlets vs. 6–7; thin, lirates and well-spaced teeth vs. lirates, evidents with some cordlets rather strong.

Raphitoma hispidella could be confused with some morphs of *R. echinata* but the last have a shorter siphonal channel, stronger inner denticles and is more robust. *Raphitoma horrida* (Monterosato, 1884) resemble in some way to *R. hispidella* but can be easily separated having only 4 cordlets above the aperture, the shorter siphonal channel and more rounded and low aperture.

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REFERENCES

- Appolloni M., Smriglio C., Amati B., Lugliè L., Nofroni I., Tringali L., Mariottini P. & Oliverio M.,

2018. Catalogue of the primary types of marine molluscan taxa described by Tommaso Allery Di Maria, Marquis of Monterosato, deposited in the Museo Civico di Zoologia, Roma. *Zootaxa*, 4477: 1–163. <https://doi.org/10.11646/zootaxa.4477.1.1>.
- Bellardi L., 1847. *Monografia delle Pleurotome fossili del Piemonte*. Memorie della Reale Accademia delle Scienze di Torino, serie 2, 9: 531–650, 4 pls. [R. Janssen, 1993, said that the journal issue was published in 1848 but that a separate was distributed in 1847; the title and pagination for the separate is: *Monografia delle Pleurotome Fossili del Piemonte*. Torino, 119 pp.].
- Bellardi L., 1877. I molluschi dei terreni terziarii del Piemonte e della Liguria. Parte II. Memorie della Reale Accademia delle Scienze di Torino, serie 2, 29: 1–373, 9 pls.
- Bouchet P., Kantor Y.I., Sysoev A. & Puillandre N., 2011. A new operational classification of the Conoidea. *Journal of Molluscan Studies*, 77: 273–308.
- ICZN. International Commission on Zoological Nomenclature, 1999. International code of zoological nomenclature. 4th Edition. International Trust for Zoological Nomenclature, London, xxix + 306 pp. on line version at: <http://www.iczn.org/iczn/index.jsp>
- Kantor Y.I. & Taylor J.D., 2002. Foregut anatomy and relationships of raphitomine gastropods (Gastropoda: Conoidea: Raphitominae). In: Oliverio M. & Chemello R. (Eds.), *Systematics, Phylogeny and Biology of the Neogastropoda*. *Bollettino Malacologico*, 38, Supplement 4: 83–110.
- Manousis T., Kontadakis C., Mbazios G. & Polyzoulis G., 2018. The family Raphitomidae (Mollusca: Gastropoda: conoidea) in the Greek Seas with the description of two new species. *Journal of Biological Research - Thessaloniki*, 25: 14. <https://doi.org/10.1186/s40709-018-0085-3>
- Monterosato M. Di, 1878. Enumerazione e sinonimia delle conchiglie mediterranee. *Giornale Scienze Naturali ed Economiche di Palermo*, 13: 61–115.
- Monterosato M. Di, 1884. *Nomenclatura generica e specifica di alcune conchiglie mediterranee*. Stabilimento Tipografico Virzi, Palermo, pp. 152.
- Monterosato M. Di., 1890. Conchiglie della profondità del mare di Palermo. *Il Naturalista siciliano*, 9: 181–191.
- Puillandre N., Fedosov A.E. & Kantor Y.I., 2017. Systematics and Evolution of the Conoidea. In: Gopalakrishnakone P. & Malhotra A., *Evolution of Venomous Animals and Their Toxins*. Springer, pp. 367–398.

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- Andrea Corso, Ottavio Janni, Lorenzo De Lisio & Carlo Fracasso. Update to the status of *Lindeni tetraphylla* (Vander Linden, 1825) (Odonata Gomphidae) in Italy, with special reference to the Molise regions. *Biodiversity Journal*, 2019, 10 (1): 7–12.
- Souheila Azzouz, Lyamine Mezedjri & Ali Tahar. Reproductive cycle of the pelagic fish Saurel *Trachurus trachurus* (Linnaeus, 1758) (Perciformes Carangidae) Caught in the Gulf of Skikda (Algerian East Coast). *Biodiversity Journal*, 2019, 10 (1): 13–20.
- R. Trevor Wilson. The Ctenodactylidae (Rodentia) in northern Africa and a new location record for *Pecinator spekei* Blyth, 1856 in Afar National Regional State, Ethiopia. *Biodiversity Journal*, 2019, 10 (1): 21–24.
- Weicai Chen, Xiaowen Liao, Shichu Zhou & Yunming Mo. First record of *Theloderma lateriticum* Bain, Nguyen et Doan, 2009 (Anura Rhacophoridae) from China with redescribed morphology. *Biodiversity Journal*, 2019, 10 (1): 25–36.
- Marlon dL. Suba, Axel H. Arriola & Grecebio Jonathan D. Alejandro. A preliminary checklist of vascular plants of Mt. Arayat National Park, Pampanga, Philippines. *Biodiversity Journal*, 2019, 10 (1): 37–46.
- Shem Unger, Zeb Hull & Mark Rollins. Diversity of vertebrate and invertebrate scavenging communities of reptile carcasses in the piedmont of North Carolina, USA. *Biodiversity Journal*, 2019, 10 (1): 47–56.
- Riccardo Giannuzzi-Savelli, Francesco Pusateri & Stefano Bartolini. A revision of the Mediterranean Raphitomidae, 8: on two poorly known species of *Raphitoma* Bellardi, 1847: *R. pumila* (Monterosato, 1890) and *R. hispidella* nomen novum (Gastropoda Conoidea). *Biodiversity Journal*, 2019, 10 (1): 57–66.

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